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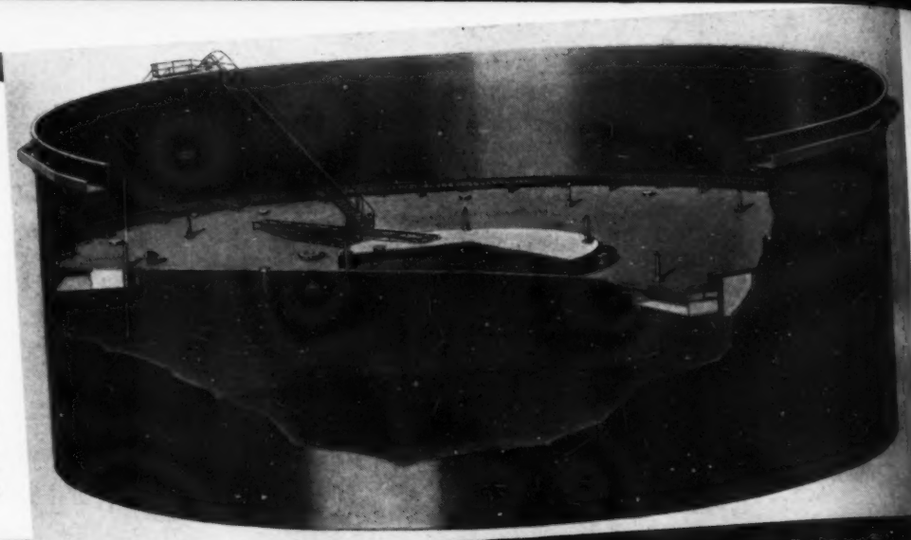

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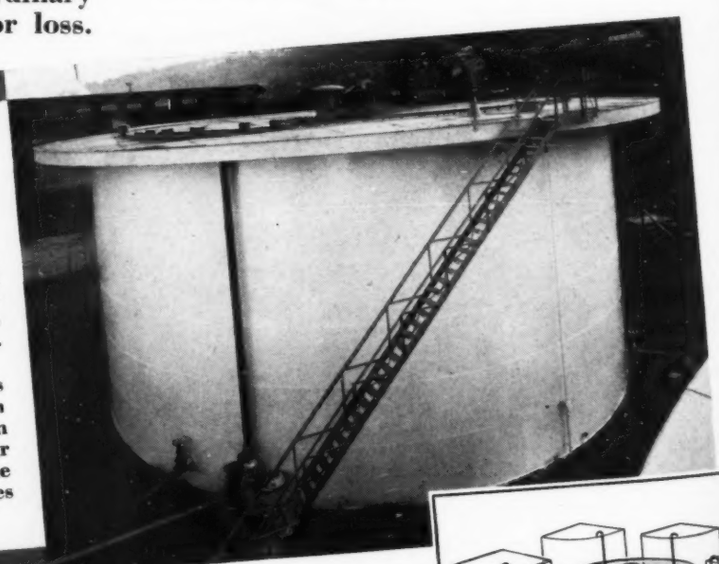

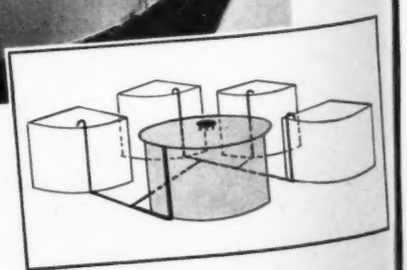

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December, 1943

THE Petroleum Engineer

VOL. XV N

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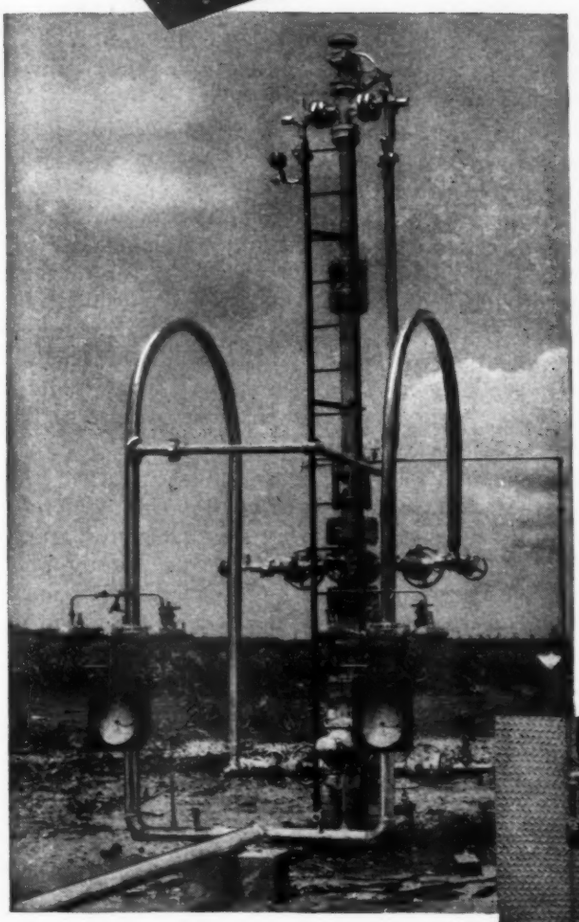

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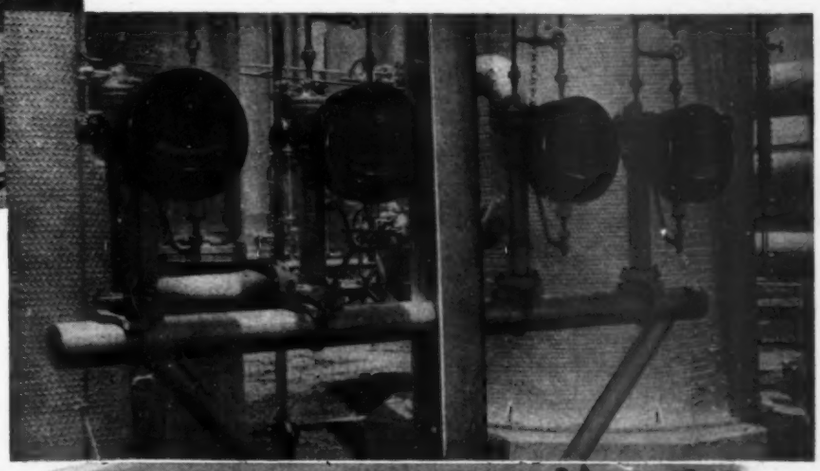

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The Course of Oil

by K. C. SCLATER

FOREIGN OIL POLICY

The secrecy that has shrouded the ultimate purposes of the Petroleum Reserves Corporation has aroused suspicion and apprehension throughout the oil industry. As a result, concern has arisen over the immediate formulation of a foreign oil policy for the United States and what form such a policy should take. On this question, the oil industry can take some comfort in the latest information from Washington. According to Edward Jamieson, Washington correspondent, a special foreign oil operations committee appointed by the Petroleum Administrator has submitted its report. The committee recommends an International Oil Compact between the oil-producing nations of the world to assure maximum production and equitable worldwide distribution of the oil resources after the war.

"The committee suggests that the United States and Great Britain, the world's two largest oil-producing nations, take the initiative in establishing the international oil compact." It would be patterned after the present Interstate Oil Compact in this country, to which a majority of the producing states are signatory.

"A compact commission and a technical agency would be created to carry out the administration of the compact. Each government would have representatives on both agencies. Also to be established would be a general conference, meeting biennially, to determine overall policies of the compact commission.

"Once the compact has been ratified by a member government, the oil industry within that country would be bound by rules and regulations laid down by the international commission. Likewise, the commission would have authority to settle disputes between member nations and oil companies of individual countries.

"A five-point foreign oil policy by the United States is recommended. Briefly it is:

1. "The American petroleum industry should be encouraged to expand its world operations and be given sufficient government backing to assure it a position of equal opportunity with nationals of other nations.

2. "Present handicaps to American development of oil resources outside of this country should be studied and removed insofar as possible.

3. "American diplomatic support of its oil industry abroad should be as strong as that given the industries of other nations by their governments.

4. "Ultimate postwar disposition of oil facilities and supplies abroad developed or paid for by this government should be designed to aid the American oil industry.

5. "Appropriate measures should be taken to assure return and earliest commercial operation of privately owned facilities in Axis-held territory."

Among other things the report "outlines a definite postwar policy for the United States government with respect to wartime oil developments undertaken outside of the boundaries of his country.

"Conceding that some of these operations, at least, will be necessary by the government itself, the committee strongly recommends that steps be taken immediately after the war to dispose of such facilities to private enterprise. A strong position on the part of the American government on behalf of this country's interests when the disposal of all wartime-developed oil facilities occurs is also urged."

Although there is no specific mention of the Petroleum Reserves Corporation, the report does set forth general policies that should guide any operations such as those planned by the PRC and recommends that such corporation be dissolved and supplanted by private operations under supervision of the International Compact as quickly after the war as possible. "The report, in emphasizing the necessity for firm support of private enterprise by the government after the war, implied that American oil companies have found it difficult to operate abroad in the past because of lack of government diplomatic backing.

"On the other hand, the committee warned that should the government seek to hold control of foreign oil operations developed during the war, international political difficulties would certainly arise. Most foreign countries look more favorably on private development of their oil resources than development by outside governments, it pointed out."

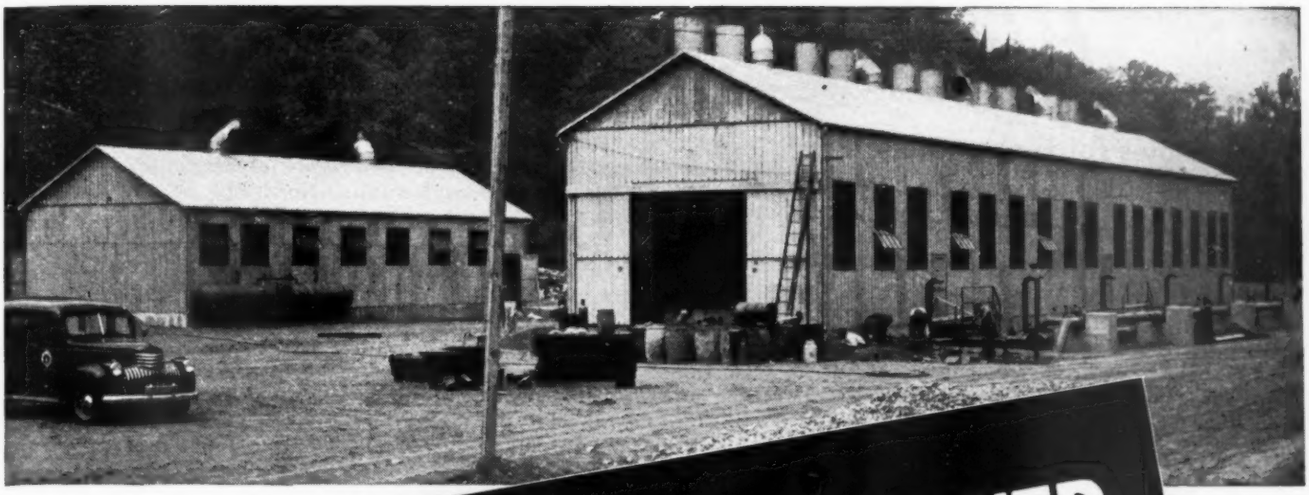
It is understood that Petroleum Administrator for War Ickes and Deputy Petroleum Administrator Ralph K. Davies look favorably upon the plan submitted and may discuss it with the President in the near future.

Here is the nucleus of a plan—an international compact—that has much to recommend it. The success of our own Interstate Oil Compact Commission, whose activities are among the most constructive and far-reaching in contributing to the well-being of the oil industry, stems from the fact that it is not a law enforcing commission, rather it is a common meeting ground of oil state regulatory officials for the discussion and solution of their common problems and an endeavor to reach common agreement. The international compact plan recognizes the principles of private enterprise; it also assures and recognizes the right of all nations to share in the oil resources of the world.

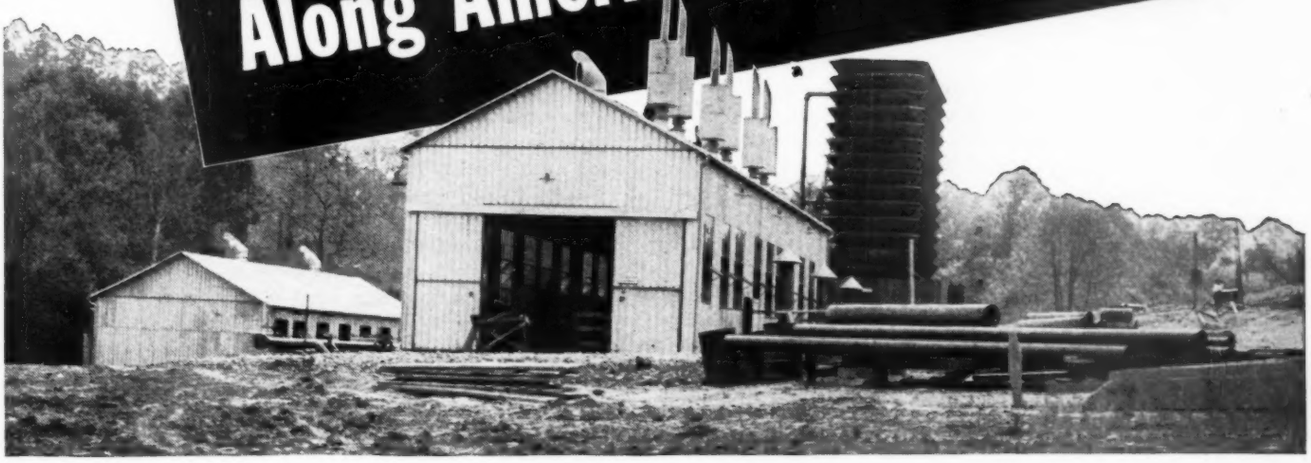
The five-point foreign oil policy by the United States as outlined, adheres to the principles of free private enterprise that an American company may engage in foreign oil operations without the threat of a working partnership with the U. S. Government. In this respect it follows the principles upon which private industry operates in the oil fields of the United States.

Whether these plans will be acceptable to the Administration hinges on the course of action agreed upon between Russia, Britain, and America at the recent Teheran Conference, with respect to the world's oil resources.

It is hoped that any committments that may have been made will not vitiate a full and frank consideration of the recommendations of this committee.



HOUSING HORSEPOWER Along America's Pipe Lines



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Highlights IN OILDOM

House Votes for Higher Crude Prices

The House of Representatives, on December 13, voted to order the Office of Price Administration to increase crude oil prices not less than 35 cents a bbl. The legislation directs OPA to fix prices not lower than 80 percent of parity. Based on present prices of about 60 percent of parity, the increase will range from 35 to 74 cents a bbl. Prices vary widely but the national average now is about $1.18 a barrel.

Oil parity is a price based on the index price of all commodities included in the Labor Department's wholesale commodity price index.

Backers of the bill changed their plans at the last minute and abandoned a drive to take oil price administration from OPA and give it to Petroleum Administrator Harold Ickes.

Details of Canol Project Given

Details of the Canol project, which has occasioned a storm of criticism and been made the subject of an official hearing, were recently disclosed in a formal announcement by the Canadian government of external affairs.

The project included the drilling of 26 test wells at the expense of the United States, with Canada acquiring the necessary land and rights-of-way, the announcement said.

A pipe line from Norman Wells, Northwestern Territories, to Whitehorse, Yukon territory, where the refinery is being built, probably will be completed in January and a pipe line from Skagway, Alaska, to Whitehorse already is in operation, according to the announcement. The Whitehorse refinery is scheduled for completion next May.

Imperial Oil, Ltd., under a contract with the U. S. government, drilled the 26 new tests in the Norman field and 23 of them found oil. In addition, 4 wells previously completed in the area were included in the project, making a total of 27 producing wells. By last July 1 a daily production of 3000 bbl. had been assured and potential production "has been considerably expanded since then," the announcement said.

The announcement contained the texts of several notes between the United States and Canadian governments, disclosing that the pipe lines, refinery, and storage facilities will remain the property of the United States government until after the war, when they will be offered for sale.

The Canadian government will have the first option to purchase the property within three months, and if it does not exercise the option, the property will be offered publicly. If there are no purchasers, disposition of the facilities will be referred to the permanent joint board on defense, with the stipulation that neither the pipe line nor the refinery be dismantled without the approval of this board.

In addition to the drilling costs, the United States is paying for construction of the pipe lines and other facilities.

Rate Aid for West Texas Oil

With a view to increasing production of petroleum products in the face of a more expensive haul by tank car as against pipe lines, refineries are being reimbursed for the difference between railroad freight and pipe line tariffs on West Texas crude oil moved by tank cars to refineries in 15 states.

Secretary of Commerce Jesse Jones said the reimbursement, which went into effect early this month, was requested by Petroleum Administrator Harold Ickes, and government payments were approved by James F. Byrnes, director of war mobilization. Payments are being disbursed through the Defense Supplies Corporation.

Refineries affected are in Ohio, Kentucky, Tennessee, Indiana, Michigan, Illinois, Wisconsin, Minnesota, Iowa, Missouri, Oklahoma, Kansas, Nebraska, North Dakota, and South Dakota.

"Where refineries are not located on pipe lines," Jones said, "the railroad freight which the refiner would have to pay to transport the oil from the pipe line terminal to the refinery will be added to the pipe line tariffs in computing the differential for which the refiners will be reimbursed.

"Companies whose taxable income places them in the excess profits bracket will not be eligible to receive reimbursement of this excess transportation expense," the announcement stated.

Sees Oil Expansion in South America

R. W. Gallagher, president of Standard Oil Company of New Jersey, who recently returned from an inspection trip to Venezuela oil producing and refining centers, states that in his opinion South America, particularly Venezuela and Colombia, "holds the greatest future for expansion of the world's oil production capacity." He predicted that production of crude oil in Venezuela would soon reach 1,000,000 bbl. daily, nearly twice the present output of 585,000 bbl. He also forecast the drilling of new oil fields in the interior of Colombia after the war, possibly along the upper reaches of the Magdalena River.

In discussing Venezuela, Gallagher said:

"New pipe lines will be built as materials are received; additional refineries will be built, and new fields will be developed along with a steady expansion of present oil producing areas."

The oil executive said the consensus among oil men is that the new Venezuelan general petroleum law will result in a great expansion of industrial activity and employment in Venezuela. The law, placed in effect March 13, 1943, specifies that oil companies granted new long-term oil concessions are to construct and maintain refineries within Venezuela after the war.

Urges Pooling of Manpower

To combat a creeping manpower crisis in the petroleum industry, Chairman William R. Boyd, Jr., of the Petroleum Industry War Council urges pooling of personnel among neighboring operators in oil field production activities.

Chairman Boyd explained that this method of meeting the approaching manpower problem was adopted by the council as part of an expansive program to counter an anticipated 85 percent loss of men between 18 and 38 years of age within the next year from a heavily burdened war industry.

He declared that a serious shortage of pumpers and other oil field workers among the 200,000 employed in the producing branch of the industry already exists; that many of these jobs cannot be classified as critical or essential under current interpretations of these classifications, and the production phase of the oil industry must therefore expect to suffer severe loss of manpower.

Divided into their specialized fields, Chairman Boyd pointed out that the 200,000 production employees in the oil industry are channeled into 10,000 in exploration other than drilling, 30,000 in drilling, and 160,000 in operating the wells of the nation. He said it appears that 35,000 new employees will have to be recruited in 1944, of which 15,000 will replace prospective losses to selective service and other industries; 2,000 for exploration; 13,000 for drilling, and 5,000 for miscellaneous oil field activities.

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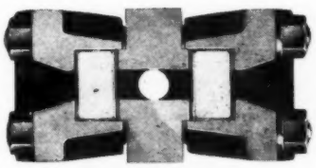

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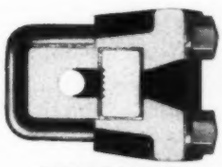

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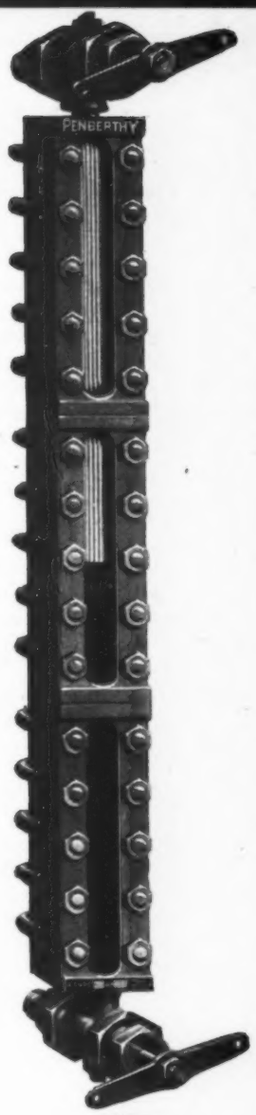

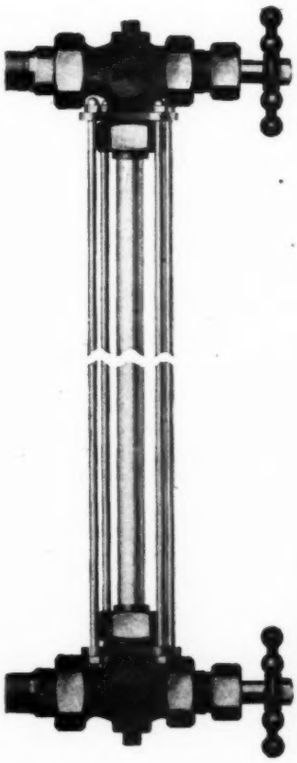

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INFLUENCE of 100-octane gasoline on the progress of the war has been so great that it might be called the Allies' "secret weapon." In just the last two years improvement in the refining of the superfuel has been decisive enough that pursuit planes now are able to take off in less distance, fly faster, climb faster, and reach higher ceilings with the present product than with the 100-octane gasoline manufactured in 1942.

Improvement in the fuel, according to the Petroleum Administration for War, has reduced production. Facilities that could produce 10,000 bbl. a day of pre-war 100-octane are able to produce only 6,600 bbl. a day of the present product. The reduction is accounted for by the more concentrated use of certain blending agents. Although still called gasoline for convenience, 100-octane is not gasoline in the ordinary sense, but a type of superfuel produced by rearranging the petroleum hydrocarbon molecules through use of catalysts.

The Eastern States Petroleum Company's $9,000,000 new 100-octane gasoline plant on the Houston, Texas, Ship Channel is nearing completion. More than 750 men are employed by the J. G. White Engineering Corporation, contractor on the job. Work began February 1 of this year and is expected to be completed by the middle of January.

The Standard Oil Company of Ohio is constructing an $8,500,000 aviation gasoline plant at its No. 1 refinery at Cleveland, Ohio. The new plant is expected to be in operation some time next spring. Its capacity, the company said, would be "more than sufficient to carry 100 heavy 4-engine bombers on a round trip between the British Isles and Berlin every 24 hr."

Capacity of the Lone Star Producing Company's gasoline plant at Trinidad, Texas, is being doubled under an enlargement program that includes the addition of equipment to make components used in aviation fuel and synthetic rubber. The plant has previously made only natural gasoline. The expansion is being made, officials of the company said, to meet increased demand for gas and for war products.

From the raw gasoline, *iso*butane, normal butane, *iso*pentane, and heavier hydrocarbons will be processed. *Iso*butane and *iso*pentane will be used for blending with refinery stocks to make aviation gasoline from 90 to 100-octane grade. The Trinidad plant takes gas from the Cayuga and Long Lake fields.

The plant absorption capacity will be increased from 80,000,000 cu. ft. of gas every 24 hr. to 160,000,000 cu. ft. The enlargement program calls for installation of a 36-in. by 64-ft. debutanizer column, a 42-in. by 101-ft. butane splitter column, and a 36-in. by 101-ft. deisobutanizer column, a 440-hp. boiler, 2 absorbers, circulating pumps, and other equipment. The 12-bay cooling tower will be enlarged to 18. Much of the equipment will be salvaged from secondhand material to conserve critical supplies.

Plans for the opening of the world's largest butadiene plant, capable of producing the raw material for one-seventh of the United Nations' wartime supply of synthetic rubber, are nearing completion. The plant, at Port Neches, Texas, is government owned, but it is operated on a non-profit basis by five oil companies—The Atlantic Refining Company, Gulf Oil Corporation, The Pure Oil Company, Socony-Vacuum Oil Company, and The Texas Company. N. W. Ayer and Son, Inc., Atlantic Refining Company's agency, is handling the public relations program. First of the two units will be placed in operation in mid-December, and the second will be ready shortly thereafter.

Through a radically new process, the amount of butadiene to be manufactured from a barrel of oil will be more than doubled, and the refinery gases remaining can be used in the production of high octane gasoline and other products. Capacity of the plant is placed at 100,000 tons of butadiene a year, sufficient to produce more than 110,000 tons of synthetic rubber. The nation's synthetic rubber goal is currently 800,000 tons annually.

To meet military and essential civilian demands for lubricating oils, the petroleum industry now has finished or under construction 8 major plants representing a total cost of about $25,000,000, Administrator Harold L. Ickes has announced.

At the outset of the war, 74 refiners were producing about 105,000 bbl. a day of base stocks for lubricating oils, Ickes said. Production is now geared to keep pace with the expanding military needs and to stockpile against the future.

The eight projects were sponsored as follows: Sinclair Refining Co., at Houston, Texas; Standard Oil Co. of California at Richmond, California; Mid-Continent Petroleum Corp., at Tulsa, Oklahoma; The Texas Corp., at Port Arthur, Texas; Quaker State Oil Refining Corp., at Emlenton, Pennsylvania; Sun Oil Co., at Marcus Hook, Pennsylvania; Champlin Refining Co., at Enid, Oklahoma; and the Gulf Oil Corp., at Port Arthur, Texas.

Contract for the construction of the Celanese Corporation of America's new $5,000,000 chemical plant near Corpus Christi at Bishop, Nueces County, Texas, has been awarded to the Gasoline Plant Construction Company of Houston, Texas. The contractor has already broken ground for the new plant on the site of about 300 acres purchased by the Celanese Corporation some time ago.

The chemical research and engineering phase of the Celanese company's expanded program, conducted in almost complete obscurity for nearly a decade under the direction of Joseph E. Bludworth, a native of Texas, in charge of research and development at the Cumberland, Maryland, plant, will gain new impetus as a result of the production of chemicals from petroleum in Texas. Started in 1934 with only a few chemists in the department, the chemical research division now numbers more than 100 specialists. Some are assisting in the construction.

Crude Runs to Stills, Production[1] and Stocks[2] of Motor Fuels
Week Ended November 27, 1943
A.P.I. Figures
(Figures in thousands of bbl. 42 gal. each)

DISTRICT	DAILY REFINING CAPACITY Potential rate	DAILY REFINING CAPACITY Percent reporting	CRUDE RUNS TO STILLS[3] Daily average	CRUDE RUNS TO STILLS[3] Percent operated	PRODUCTION[3] Total production	Total stocks
*Combined: East Coast, Texas Gulf, Louisiana Gulf, North Louisiana-Arkansas, and Inland Texas	2,444	88.7	2,147	87.8	13,707	80,201
Appalachian	177	85.5	149	89.9	786	4,347
Ind., Ill., Ky.	824	85.2	762	92.5	4,689	25,441
Okla., Kans., Mo.	416	80.1	335	80.5	2,095	11,277
Rocky Mt.	149	42.6	99	88.2	684	2,589
California	817	89.9	769	94.1	5,106	65,712
TOTAL U. S.— Nov. 27, 1943	4,827	86.4	4,261	88.3	27,067	189,567
TOTAL U. S.— Nov. 20, 1943	4,827	86.4	4,192	86.9	27,308	188,922
U. S.— Nov. 28, 1942	.....	.....	3,740	.....	24,085	216,129

*At the request of the Petroleum Administration for War.

[1]Production—total of gasoline at refineries including natural and blended; kerosine, gas and distillate fuel oil, and residual fuel oil.

[2]Stocks—at refineries, bulk terminals, in transit, and pipe lines of finished and unfinished gasoline; kerosine, gas oil and distillate fuel, and residual fuel oil.

[3]Figures on production and stock include reported totals plus an estimate of unreported amounts and are therefore on a Bureau of Mines basis.

A LESSON IN WATER COOLING

LESSON 9 OF A SERIES

HOT AIR RECIRCULATION

"Hot air recirculation" is an undesirable condition which occurs at intervals or continuously in those mechanical draft cooling towers not properly designed to prevent it. It is the re-entry, into the tower's fresh air intakes, of discharged air which is heat-laden from previous passage through the tower.

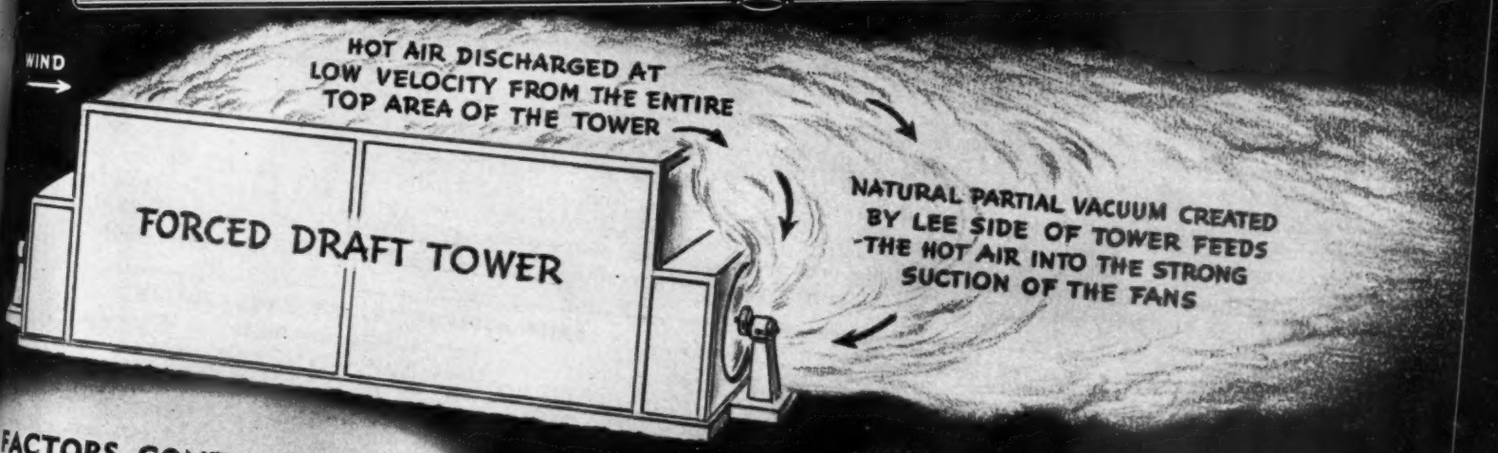
The net result of recirculating hot used air is to increase the wet bulb temperature and total heat content of the entering air. Its effectiveness as a cooling medium is thus reduced, causing the water temperatures to rise.

Recirculation of hot air increases water temperatures from a fraction to as much as 6 or 7 degrees in extreme cases. The following example is typical of the effect of recirculation upon cooling tower performance and investment:

	Performance as Designed	Performance with Recirc.
Hot water temperature	98 F	100.0 F
Cold water temperature	80 F	82.0 F
Wet Bulb temperature	73 F	75.5 F
Loss of tower effectiveness	0%	15%
Loss of investment	0%	15%

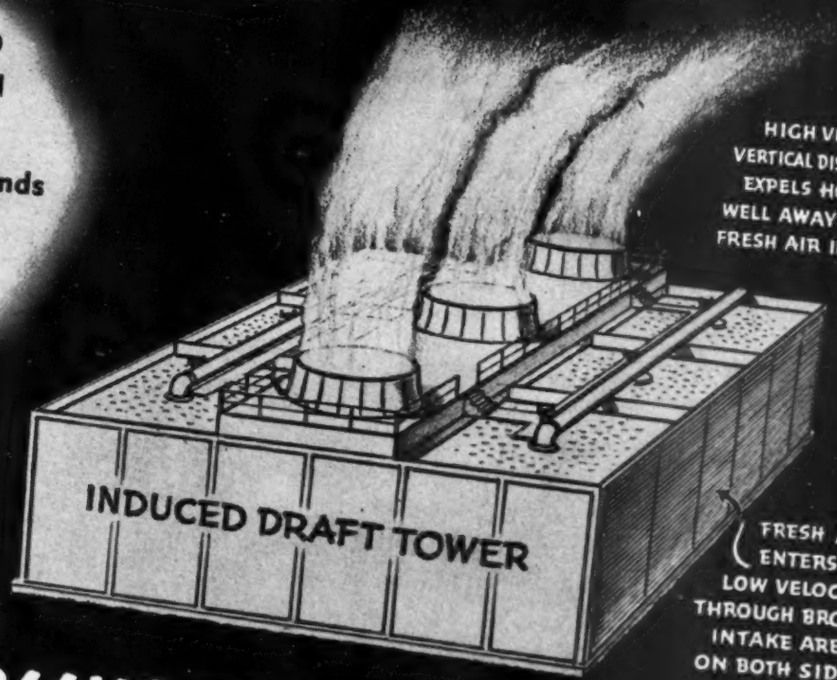
This negative feature of mechanical draft cooling towers is confined almost entirely to the forced draft type, particularly those having large fans and great width. The low discharge velocity of the hot used air leaving the broad top area of the forced draft tower permits it to be easily blown, by external winds, into the suction of the forced draft fans.

The induced draft type of cooling tower, with fans discharging vertically at great velocity, expels the hot used air high into the atmosphere and away from the fresh air inlets.


WIND
HOT AIR DISCHARGED AT LOW VELOCITY FROM THE ENTIRE TOP AREA OF THE TOWER
FORCED DRAFT TOWER
NATURAL PARTIAL VACUUM CREATED BY LEE SIDE OF TOWER FEEDS THE HOT AIR INTO THE STRONG SUCTION OF THE FANS

FACTORS CONTRIBUTING TO HOT AIR RECIRCULATION IN FORCED DRAFT TOWERS:

1. High velocity cross-wise winds
2. Extreme width
3. Fans on both sides of tower
4. Improper location with respect to other structures


HIGH VELOCITY VERTICAL DISCHARGE EXPELS HOT AIR WELL AWAY FROM FRESH AIR INTAKES
INDUCED DRAFT TOWER
FRESH AIR ENTERS AT LOW VELOCITY THROUGH BROAD INTAKE AREAS ON BOTH SIDES

MARLEY COOLING TOWERS

THE MARLEY COMPANY INC.
KANSAS CITY, KANSAS

MAJOR *Oil Field* ACTIVITIES

Indiana. Listed as a pool opener for Spencer County is the W. B. Bateman No. 1 Ernst, SE NE SW 8-6s-4w. During initial test the discovery of the Newtonville pool pumped 10 bbl. of oil in 24 hr. from the Jackson sand at 796 to 803 ft.

Louisiana. Final completion has been made on Continental and Humble No. 3 Pardee Lumber Company, 20-4s-1w, discovery well in the Reddell area of Evangeline Parish, coastal Louisiana. The well flowed 156 bbl. of oil daily from the Tate sand in the Sparta formation at 9,960-10,000 ft.

Louisiana. A new oil strike in DeSoto Parish was made by Texas Mineral Lands Company at its No. 1 Scott, which came in flowing 15 bbl. of oil an hr. through 2-in. tubing from the Tokio sand at 2781 ft.

Illinois. A new discovery is J. W. Murchison No. 1 Franklin County Coal Company, NE SW SW 11-5s-2e, northeast of Whittington in Franklin County. When acidized the well filled with 50 ft. of oil and was swabbed later. Production is from lower O'Hara lime, which was perforated following a plugback to 2874 ft.

Texas. Magnolia Petroleum Company No. 1 Ingram, James Richardson survey, 4 miles north of Pettus, showed 1110 ft. of oil and 150 ft. of fluid on a drillstem test at 6811-14 ft.

Louisiana. Opening of a new oil field is indicated by the setting of casing in Amerada No. 1 Bertinot-Quebedeaux, a wildcat in 44-7s-5e, in the Arnaudville area of St. Martin Parish. The well was drilled to 10,700 ft.

Texas. A new wildcat strike for Brooks County was in prospect with a good oil show at the Humble Oil and Refining Company No. 1 Scott and Hopper in survey 107, 19 miles northwest of Encino. From sand at 6309-14 ft., 495 ft. of oil was recovered in 20 min.

Oklahoma. Called a new Mississippi lime pool opener, W. C. Norris No. 1 wildcat in SW 18-20-12e, northwest of Tulsa, in southeastern Osage County, pumped 32 bbl. of oil in 11 hr. In lime from 1984-97 ft., the well will be deepened and acidized. A connection has been made to the Mid-Continent Pipe Line Company line.

Oklahoma. Great Lakes Carbon Company No. 1 Jerome, CSW SW 16-20-2w, east of the Lucian pool, promises a new pool in Noble County. The wildcat had the Oswego lime from 4678 to 4844 ft. and on a test averaged 3 bbl. of oil an hr. flowing naturally through 10/64-in. tubing choke.

Kansas. Cities Service Oil Company opened a new pool in Barton County with No. 1 Eveleigh, NEC SE 11-18-14w. The discovery well has drawn an initial potential of 434 bbl. of oil daily from the Conglomerate at 3306-16 ft.

Kansas. Ness County has a new pool opened by Sohio Oil Company No. 1 Frevile, CSE SE 22-16-25w, 8 miles north of the Aldrich pool. On preliminary tests the well produced 20 bbl. of oil an hr. from the acidized Mississippi lime. Total depth of the hole is 4562 ft. but it was plugged back to 4550 ft.

Indiana. Bennett Brothers No. 1 Spencer, NE SE SW 32-6s-14w, promises a new pool 6 miles north of Mt. Vernon. While testing Tar Springs sand at 2142-49 ft. the well swabbed 15 bbl. of oil an hr. through casing. Total depth of the hole is 2150 ft.

Kentucky. Discovery well of the Geneva pool in Henderson County has been completed. Several miles from any other production Woods and Lacey No. 1 Bauldauf, 15-Q-22, in 24 hr. pumped 10 bbl. of oil and 100 bbl. of water from Tar Springs sand at 1869-78 ft.

Oklahoma. Gulf Oil Corporation No. 1 Hopkins, CNW SE 8-8-20w, Washita County, opened a new pool 26 miles from any other production. It flowed 140 bbl. of oil in 7½ hr. Production is from two producing zones in the Granite Wash, one at 5540-5620 ft. and the other at 6425-6591 ft. The well was plugged back from a total depth of 9971 ft.

AVERAGE CRUDE OIL PRICES

California		**Louisiana**	
Kettleman Hills	$1.23-1.29	Rodessa	$ .88-1.20
Playa Del Rey	.80- .87	Gulf Coast	.93-1.36
Coalinga	.73-1.13	North Louisiana	.98-1.30
Wilmington	.68-1.24		
Montana	1.00-1.15	**Illinois**	1.22-1.37
Wyoming	.45-1.15	**Kentucky**	1.32-1.43
Colorado	1.05-1.07		
New Mexico	.70-1.15	**Indiana**	.85-1.25
Texas		**Ohio**	
North Central	.97-1.25	Lima	1.50-1.60
Panhandle	.70-1.12		
West Texas	.80-1.27	**Michigan**	1.24-1.44
Gulf Coast	.93-1.48		
Darst Creek	1.14	**Pennsylvania**	
East Texas	.80-1.27	Bradford	3.00
Talco	.79	Southwest	2.65
Kansas	.93-1.25	Eureka	2.59
Oklahoma	.75-1.25	Buckeye	2.30
Arkansas	.94-1.36	Corning	1.31

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

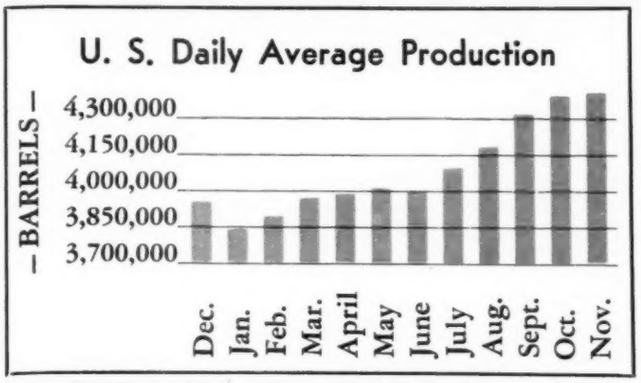
(Figures in bbl. of 42 gal. each)

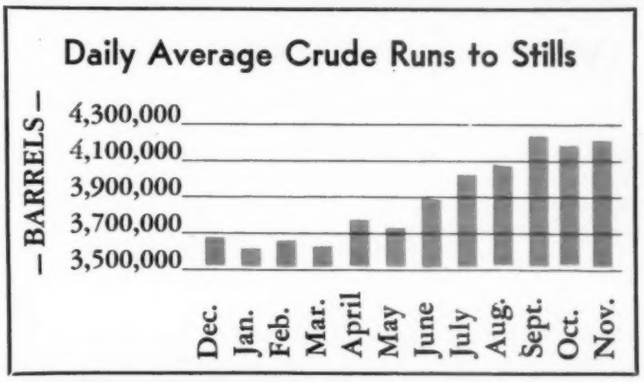
	[1]P.A.W. Recommendations November	ACTUAL PRODUCTION Week Ended Nov. 27, 1943	Week Ended Oct. 30, 1943	Week Ended Nov. 28, 1942
Oklahoma	318,000	[2]325,800	329,400	365,700
Kansas	285,000	[2]273,200	274,650	299,100
Nebraska	1,600	[2] 1,700	1,700	2,950
Panhandle Texas	.....	85,500	88,100	89,800
North Texas	.....	141,900	138,300	137,600
West Texas	.....	359,750	354,050	212,750
East Central Texas	.....	142,950	135,250	95,800
East Texas	.....	376,400	368,700	354,800
Southwest Texas	.....	298,100	288,150	176,550
Coastal Texas	.....	524,600	519,350	313,400
TOTAL TEXAS	1,881,000	1,929,200	1,891,900	1,380,700
North Louisiana	.....	78,800	79,600	96,550
Coastal Louisiana	.....	272,200	279,000	228,700
TOTAL LA.	353,700	351,000	358,600	325,250
Arkansas	76,900	78,450	78,950	73,600
Mississippi	49,000	49,650	46,450	60,950
Illinois	205,000	218,100	214,550	255,650
Indiana	14,000	13,500	13,300	16,200
Eastern	78,500	69,850	76,900	75,050
Kentucky	24,500	24,550	25,500	15,300
Michigan	56,000	53,750	51,800	58,400
Wyoming	98,000	102,850	97,750	90,700
Montana	23,000	21,300	21,350	22,550
Colorado	7,000	7,250	7,100	7,000
New Mexico	110,500	112,900	112,550	95,800
TOTAL EAST OF CALIF.	3,581,700	3,633,150	3,602,450	3,144,900
California	795,000	780,500	780,500	733,100
TOTAL U. S.	4,376,700	4,413,650	4,382,950	3,878,000

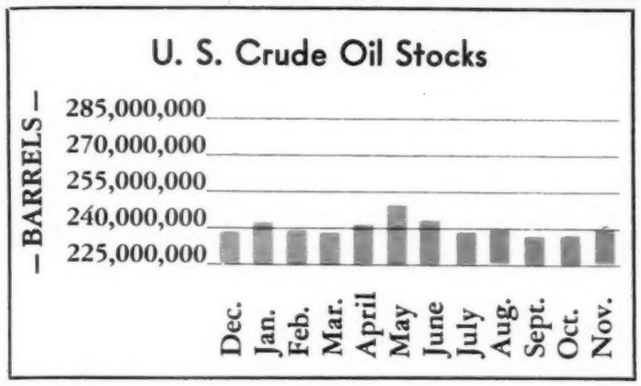
[1]P.A.W. recommendations and state allowables represent the production of crude oil only, and do not include amounts of condensate and natural gas derivatives to be produced.

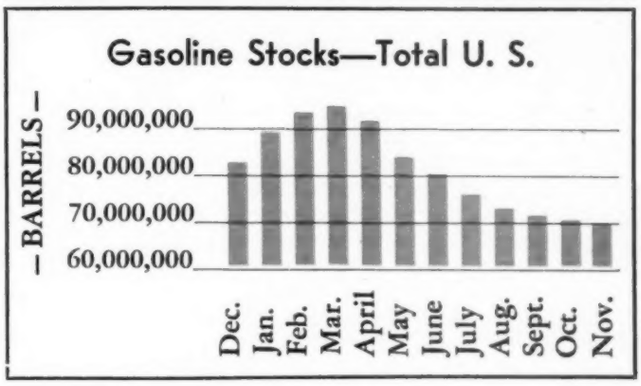
[2]Oklahoma, Kansas, Nebraska figures are for week ended November 25.

PETROLEUM *Statistics* AND FIELD *Operations*









Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for November, 1943

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
Eastern Texas	20	15	12	....	3500-3700	2	40	Rotary
Gaines County	4	3	5	....	4400-5584	2	22-35	Rotary
Hockley County	11	7	9	....	4800-6850	2	20-30	Rotary
Ector County	17	14	7	....	3675-4377	2 or 3	32-36	Rotary
Panhandle	14	12	6	....	1700-3900	2	40	Rot.-Cab.
Nueces County	8	6	7	....	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	15	11	5	....	3730-3935	2	42-43	Rot.-Cab.
Hawkins Field	11	8	8	....	4495-4912	2	19-29	Rotary
OKLAHOMA								
Okfuskee County	7	3	4	....	2150-4125	2 or 3	38	Rotary
KANSAS								
Russell County	10	8	3	....	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	9	8	2	....	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	7	2	4	....	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	151	117	96	104	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	....	....	4	....	3150-4030	2	30-34	Rot.-Cab.
CALIFORNIA								
Kern County	27	....	11	....	1840-11,450	2 or 4	14-30	Rotary
Wilmington County	4	....	....	....	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for November, 1943

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1942 (In barrels)
	November	October	November	October	November	October	November	October	November	October	
Arkansas	22	14	18	11	36	17	15	8	27	14	26,560,000
California	97	77	91	69	84	61	43	31	43	22	248,250,000
Illinois	151	136	117	118	90	72	96	82	104	91	105,768,000
Indiana	38	40	23	35	42	30	12	4	14	10	6,680,000
Kansas	184	176	121	137	51	45	40	20	....	11	96,920,000
Kentucky	69	58	47	37	26	15	66	....	....	....	4,503,000
Louisiana	46	41	35	32	28	20	21	8	30	18	125,450,000
Michigan	57	47	46	39	27	22	17	11	....	14	21,568,000
Mississippi	2	4	....	1	....	....	....	....	....	....	27,605,000
Montana	15	11	9	7	....	....	....	4	....	....	8,998,000
Nebraska	1	....	....	....	8	4	....	....	....	....	1,367,000
New Mexico	24	18	15	16	14	10	....	....	....	....	31,875,000
New York	111*	91*	80*	86*	53	47	....	22	....	....	5,132,000
Ohio	60	65	45	51	43	31	....	18	....	....	3,480,000
Oklahoma	123	112	84	91	51	42	14	16	56	46	138,750,000
Pennsylvania	212*	210*	126*	184*	182	160	....	....	....	....	17,256,000
Texas	344	318	267	278	300	302	306	241	310	296	476,560,000
West Virginia	73	62	62	54	29	22	3	3	5	15	3,780,000
Wyoming	5	8	3	6	4	5	1	2	1	13	32,778,000
Total	1634	1488	1189	1252	1068	905	634	470	590	550	1,383,280,000

*Includes water-intake and pressure wells.

MAJOR *Pipe Line* ACTIVITIES

WORK began on the Texas end of the new South Texas-West Virginia natural gas pipe line near the first of the month. Gardiner Symonds, president of Tennessee Gas and Transmission Company, stated that the operating company expects to have the line completed by August 31, three months before the deadline. Ray Fish, formerly with Stearns-Roger Manufacturing Company, is vice president and general manager of the company.

Certification of the 24-in. line has caused a furor of claims and counterclaims since the Federal Power Commission issued a certificate of public convenience and necessity September 25. Despite protests of Texas officials and the frank opposition of Gov. Coke Stevenson, no protest was filed against the Guadalupe River crossing when the governor was notified by U. S. Army engineers that any interference to navigation would be considered.

Symonds claims that an impetus to the Texas chemical industry will result from stripping the gas of its hydrocarbon fractions before the gas is placed in the line. Only the heat values in the gas will be sent through the line. Consensus of opponents to the line was that Texas would be drained of a natural resource that would bring more industries to the state.

Contracts made so far for construction of the 1228-mile line and the 8 compressor plants have been awarded to the following:

Williams Brothers Corporation, Corpus Christi to Edna, Texas, approximately 120 miles; N. A. Saigh Company, Edna to Cleveland, Texas, 120 miles; O. C. Whitaker Company, Cleveland to the Saline River crossing, 120 miles. The rest of the line is divided between Williams Brothers and Bechtel-Dempsey-Price, with the latter firm having the eastern section.

Stearns-Roger Manufacturing Company of Denver was awarded contracts to construct 8 compressor plants and a dehydrating plant at the west end of the line. The stations will be spaced approximately 200 miles apart. Henry Wade is in charge of the Stearns-Roger contracts.

Brokaw, Dixon and McKee, Houston, Texas, are inspectors for the line. They were instrumental in initiating the promotion of the line three years ago. Seven hundred miles of right-of-way have been purchased from Hope Natural Gas Company, which had applied to build a similar line.

Stanolind Pipe Line Company is making rapid progress on its new 383-mile pipe line from Sundown, in West Texas field, to Drumright, Oklahoma. Welding operations are underway on the 16-in. and sufficient pipe has been distributed at railheads for all six gangs organized by the contractors to keep busy.

Sour crude from the Permian Basin will be moved through the line to help supply refiners in PAW District 2 with oil to replace the steady loss in production through the middlewestern states. The War Production Board has also approved a plan by which Stanolind and Magnolia Pipe Line Company will cooperate in moving crude oil from Wasson-Slaughter pools of West Texas. Ten miles of 8-in. line will be laid east of Wasson to tap the Magnolia's 8-in. line to Corsicana, and thus 16,000 bbl. of oil will move north to the Stanolind and 20,000 bbl. to the Magnolia.

A payment of a $15,000 damage claim was announced by the Office of Price Administration through the district attorney of St. Louis, Missouri. The statement said that the Valley Steel Products Company of St. Louis and its branch, the Centralia Pipe and Supply Company, Centralia, Illinois, made the payment. The two firms of one partnership were charged with selling reusable pipe above the maximum prices fixed by OPA regulations. Joint action was taken against the firms.

McBride Refining Company of La Blanca has completed an oil gathering system for the Sullivan City, Texas, field in Hidalgo and Starr counties at a cost of about $12,000. The line was built to take the place of trucks that formerly took crude oil from the field to the La Blanca refinery east of Edinburg.

To prevent long distance trucking from Starr and Hidalgo counties to the Rado refinery at McAllen, another pipe line was completed recently.

Another break was reported in the "Big Inch," spreading a flow of oil through a section of country near Hamilton, Ohio. It was said that at least 40 miles of oil had been lost from the 24-in. crude oil pipe line and immediate efforts of engineers and repair crews were concentrated in preventing fires. Most of the oil flowed into Dry Creek and land was only slightly affected by it. Eastward flow of the oil was cut at Greensburg, Indiana, 25 miles west of the point where the break occurred until repairs were completed.

Application has been made to the PAW's transportation committee by Sun Pipe Line Company for approval of construction of a 144-mile pipe line system that would link the Sun Oil Company's various properties in southwest Texas with Corpus Christi, Texas. The company proposes to lay 84 miles of 8-in. line from Harbor Island to the Seeligson area, with a 6-in. extension of 60 miles to its holdings in Starr County and intermediate points. Production for Sun Oil Company is approximately 4610 bbl. daily in the Rio Grande Valley district; 4625 bbl. in the Mirando area, and 2100 bbl. near Beeville. Gains in production are indicated by recent discoveries.

Tanker construction increased by three vessels in October over September, or 22,540 deadweight tons of ships. During the month yards delivered 16 standard tankers, 19 emergency tankers, 3 T-1 or coastal tankers, and two private tankers.

Mid-Continet Pipe Line Company, an affiliate of Mid-Continent Petroleum Corporation, has completed a 14-mile pipe line from the new pool in Cleveland County, Oklahoma. Discovery well of the new field is the Mid-Continent No. 1 Edgar Harris, producing from the second Wilcox sand. Seven miles of the line is 4-in. and the other seven are 6-in. pipe. The line skirted the east edges of Oklahoma City field to reach the well, encountering numerous street and rail crossings to go under. The Pipe Line Service Company of Oklahoma City handled the job and under the supervision of J. Marston Linehan, manager of Mid-Continent Pipe Line Company, the line was laid in 15 days.

Preparations are now underway to construct a 82½-mile oil pipe line from the Elk Basin and Frannie fields in southern Montana to refineries in Laurel and Billings, Montana. The new line will have a capacity of 15,000 bbl. of crude oil daily and will be financed by the Yale Oil Pipe Line Company of Denver, Colorado, at a cost of approximately $830,000 and operated by the same company.

The new pipe line will cover the following route: a 6-in. line from Elk Basin field northeastward for 12 miles to a junction point with a 6-in. lateral line 3½ miles long from the Frannie field; thence an 8-in. line northward for 45 miles, at which point the main line feeds into two 6-in. laterals, one going 10 miles to Billings and the other 12 miles to Laurel.

THE Petroleum Engineer

DECEMBER, 1943

Use of Plastics in Water Control

☆ Liquid plastic that hardens in well employed to reduce water-oil ratios

PETROLEUM ENGINEER Exclusive Feature

by D. G. Hefley and P. H. Cardwell

Dowell Incorporated

PLASTICS, one of the great chemical developments of the present time, are an important and far reaching adjunct in the development of oil producing methods. Water control in producing wells, a major problem of long standing in many fields, is now being accomplished through the application of plastics.

In the past, many and varied methods have been employed for the exclusion of unwanted fluids from wells. Much of this work has been done by applying cement to a selected portion of the formation to render that portion impermeable, while leaving other portions of the formation unaffected. Many methods are known for applying the cement, and these have been described in detail by Torrey[1] and by Montgomery.[2] Marking a departure from these methods is a new plastic plugging agent designed especially for use in oil wells. The method of its application in wells and the results obtained in reducing water-oil ratios indicate the scope of its usefulness.

Several chemical solutions, or mixtures, have been suggested for plugging formations. These solutions are clear liquids, containing no suspended matter of any kind. Such solutions are designed to set up and harden in or over the pores of the formation or to react with some material already present in the formation and form a voluminous precipitate that acts as a pore plugging material. Work along this line has been reported by Kennedy[3, 4] and by Lehnhard and Reimers[5], who describe methods that have been used in such work and also give the results of a number of treatments that have been made. Sodium silicate gels were used in much of this work and, although satisfactory results were obtained in a number of instances, the material when solidified did not obtain the hardness that was desired. To overcome this difficulty, synthetic organic resins, or plastics, have been developed that can be introduced into the well as a liquid and subsequently will polymerize into a solid having a hardness comparable to many of the well known plastic articles in every day use, at the same time forming a perfect seal.

Liquid Plastics

There are many plastics forming liquids available that are mobile at ordinary temperatures and are of such a nature that of themselves they spontaneously undergo polymerization, condensation, or association reactions until the whole liquid becomes an insoluble, strong, solid plastic. Examples of these liquid plastics, suitable for oil well use, are substances such as unpolymerized styrene, vinylidine chloride, partially condensed phenol-formaldehyde, vinyl esters,[6] and the ester of maleic acid and diethylene glycol.[7] The liquid plastics are fairly stable at ordinary temperatures, but when properly treated or subjected to temperature encountered in oil wells, the rate of polymerization, condensation, or association is increased, resulting in the liquid becoming a solid in a relatively short time. The time required for the liquid plastic to make the transition from a liquid to a solid state depends among other factors upon the nature of the plastic and the temperature to which it is subjected.

The temperature range at which a specific liquid plastic material can be used is rather limited, because with some plastics an increase of 10°F. usually will reduce the setting time about one-half, and likewise, a decrease of 10°F. will double the time required for the plastic to set or become a hard solid. Thus, the usable range of many of the liquid plastics is about 30°F., because a liquid that requires two hours to set at a certain temperature will require some 16 hours to set at a temperature 30° lower.

Means of increasing the temperature range at which a liquid plastic can be used are available by proper adjustment of the chemical compositions of the plastic materials. Fig. 1 illustrates the effect of such adjustments on the set-

ting time of the plastic used in the East Texas field.

The liquid plastics now in commercial use are insoluble in brine and crude oil and the plastic, after it has set, is not affected by brine or crude oil. The solidified material does not deteriorate with time. The physical properties of the liquid plastic used for water shut off in the East Texas field are given in Table 1.

TABLE 1

Physical properties of liquid plastic used for water control in East Texas

Temperature, °F.	Liquid plastic No. 1		Liquid plastic No. 3	
	Specific gravity	Viscosity centi-poises	Specific gravity	Viscosity.. centi-poises
85	1.206	275	1.280	3950
115	1.204	92	1.279	780
130	1.203	58	1.278	400
145	1.202	38	1.277	216
160	1.201	26	1.277	122
175	1.201	19	1.276	72

Use in East Texas

Plastics are now being widely used in the East Texas field for the control of water in producing wells.[8] That this development has passed beyond the experimental stage is attested by the fact that more than 225 such treatments have been made to November 1, 1943. Practically all these treatments were made for the purpose of shutting off bottom hole water. The technique of application that has proved most satisfactory is to place the plastic on the bottom of the well by means of a special, positive displacement dump bailer, and then allow the material to harden. If insufficient fill up is obtained, the process is repeated until the well has been plugged back to the desired point.

A summary is given in Figs. 2 and 3 and in Tables 2 and 3 of the first 100 plastic plug back jobs in the East Texas field wherein only a portion of the open hole was sealed off. This summary does not include any of the other types of plastic applications such as sealing a leaking cement plug or plugging the entire open hole with subsequent perforation of the casing. Briefly, these data show that out of 100 wells, 65 have had the water completely shut off, 18 have had the water reduced by at least 50 percent whereas in only 17 wells has the water reduction been less than 50 percent.

The results given in Table 2 show that the percentage of successful treatments is somewhat dependent on the water production of the well before treatment, the highest percentage of successful jobs obtained on wells making the least amount of water before treatment. On wells making less than 25 percent water before treatment more than 90 percent of the jobs can be classed as successful, whereas on wells making between 25 and 50 percent water more than 80 percent can be classed as successful. The above generalizations are drawn only from the percentage of water the well is producing, and do not take into consideration pay thickness or amount of pay plugged off.

In Fig. 2, the percentage of water that the well produced before treatment is plotted against the pay thickness of the well. It is to be noted from this graph that the completely successful treatments, that is, the 100 percent water shut offs, are concentrated in the lower part of the graph. The partial and non-successful treatments are in the upper part of the graph, in which part are located the wells making high percentages of water. This graph shows, as does Table 2, that in the wells making less than 50 percent water there is an excellent possibility of completely shutting off the water. For wells making more than 50 percent water, there is still better than a 50-50 chance that the water will be reduced by more than one-half.

Similar conclusions can be drawn

Fig. 1. Setting time at various temperatures of liquid plastic used in the East Texas field

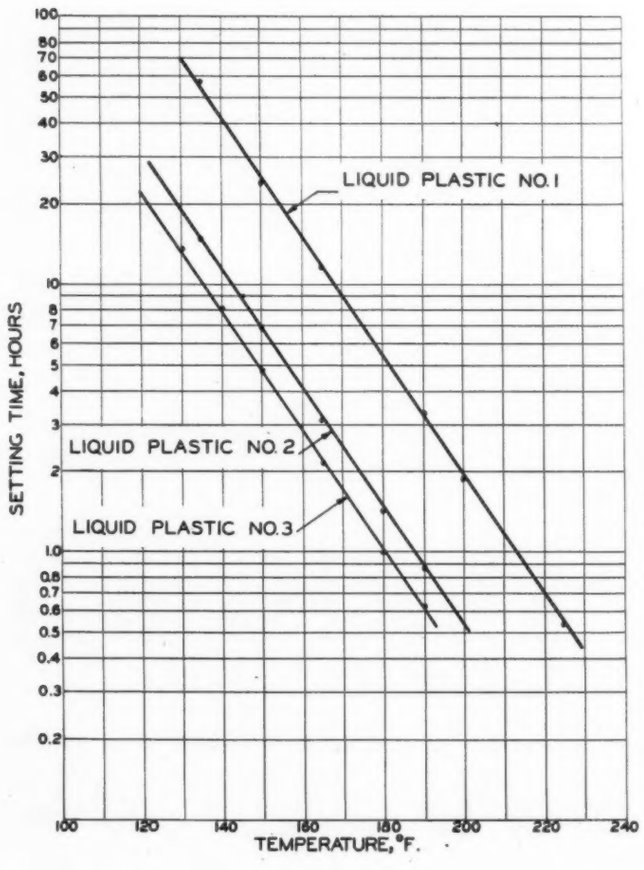
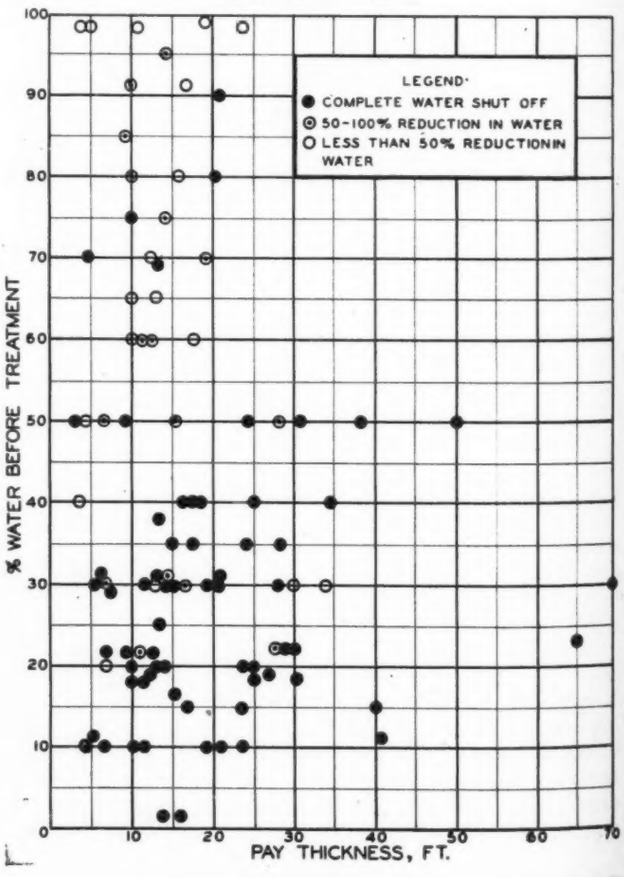


Fig. 2. Influence of water production before treatment and pay thickness on results of 100 plastic plug jobs in the East Texas field


LEGEND·
● COMPLETE WATER SHUT OFF
⊙ 50-100% REDUCTION IN WATER
○ LESS THAN 50% REDUCTIONIN WATER
% WATER BEFORE TREATMENT
PAY THICKNESS, FT.

from Fig. 3, in which the percentage of water the wells produced before treatment is plotted against percentage of pay plugged off. The greatest number of successful treatments are the ones in which the wells made less than 50 percent water before treatment and 50 to 90 percent of the pay was plugged off.

The data given in Table 3 would seem to indicate that any well having a pay section of more than 20 ft. has an excellent chance for successful treatment with liquid plastic, regardless of the amount of water being produced. This conclusion, however, may be drawn from insufficient data as it will be noted on closer examination that only three wells having more than 20 ft. of pay and making more than 50 percent water are reported in this tabulation. For the wells having 20 ft. or less of pay and making less than 50 percent water, there is an excellent chance (at least 80 to 90 percent) of completely shutting off the water. It probably will be found in the future, after a greater number of plastic plug treatments have been completed, that for wells with more than 20 ft. of pay equally successful treatments can be made, even though the wells are making more than 50 percent water.

Liquid plastic to control water is by no means limited to the single application considered in preparing the data for Tables 2 and 3 and Figs. 2 and 3. Among other well conditions in which a liquid plastic has been employed may be mentioned the treatments whereby the plastic is placed on top of a leaking cement plug for the purpose of sealing the crevices and channels between the cement and the formation. In this case, the cement is not drilled out ahead of the plastic treatment. Another plastic application, when pay is present behind the casing, is to plug back with the plastic into the casing and follow by gun perforating above the plastic. Other wells have been successfully treated by bringing the plastic up to or into the casing and then drilling out some of the set plastic, followed by gun perforating the formation. Plastic has also been used in wells containing liners, screens, and perforated pipe with every good success.

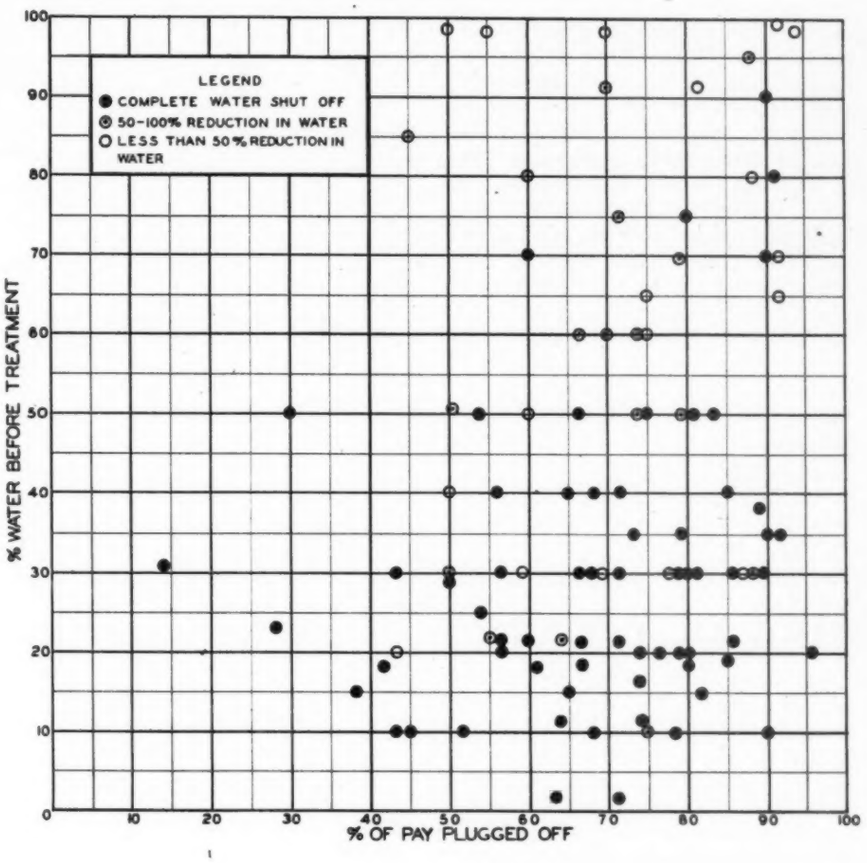


Fig. 3. Influence of water production before treatment and percent of pay plugged off on results of 100 plastic plug jobs in the East Texas field

Besides the East Texas field, liquid plastic has been used in other oil fields, among which are the Cayuga and Talco fields in Texas, Rodessa and Jena in Louisiana, Troy in Arkansas, and a few fields on the Gulf Coast.

TABLE 2

Analysis of results on 100 plastic plug jobs in East Texas showing influence of water production before treatment

Amount of water before treatment.....	0-25 percent		25-50 percent		50-75 percent		75-100 percent		Totals	
	No. of wells	Percent	No. of wells	Percent	No. of wells	Percent	No. of wells	Percent	No. of wells	Percent
Complete water shut off.....	31	89	23	77	8	40	3	20	65	65
50-100 percent reduction in water	3	8	3	10	7	35	5	33	18	18
Less than 50 percent reduction in water..	1	3	4	13	5	25	7	47	17	17
Totals.....	35	100	30	100	20	100	15	100	100	100

TABLE 3

Analysis of results on 100 plastic plug jobs in East Texas showing influence of pay thickness

Pay thickness	3-10 ft.		10-20 ft.		20-30 ft.		30-70 ft.		Totals	
	No. of wells	Percent	No. of wells	Percent	No. of wells	Percent	No. of wells	Percent	No. of wells	Percent
Complete water shut off.....	14	52	24	58	18	82	9	90	65	65
50-100 percent reduction in water	7	26	9	22	2	9	0	0	18	18
Less than 50 percent reduction in water .	6	22	8	20	2	9	1	10	17	17
Totals.....	27	100	41	100	22	100	10	100	100	100

Treating Method

Most plastic plugging treatments are made by placing the material on the bottom of the well by means of a special dump bailer. The bailer used on a majority of these treatments was made from a 4 in. O.D. tube holding approximately 10 gal. The bailer is run on a wire rope, which is wound on a winch carried on the service company's truck. A measuremeter is used on the wire rope in order that accurate measurements of depth may be made.

To make a plastic plugging treatment, the usual practice is to remove the tubing and then clean out any cav-

ings or debris that may be present in the well. An electric log is then run in order to determine the top of the producing sand. This information is important, as it prevents plugging the well back too far and shutting off all oil production as well as all water. The distance the well is to be plugged back is determined from the available well data and a quantity of the liquid plastic material, sufficient to fill the well to the desired point, is introduced into the well by means of a pump bailer. The material is allowed to harden and a measuring line is run to determine the exact amount of fill up that has been obtained. If it is found that the fill up is not as much as was calculated, a second stage of plastic is usually required. This process is repeated as many times as may be needed to obtain the desired fill up in the well. Fig. 4 illustrates a typical well in the East Texas field, and shows the condition at the bottom of the well before and after a plastic plugging treatment.

On some wells, it has been found necessary to add oil or water to the well immediately after dumping the plastic so that the plastic is held firmly against the formation until it has solidified. In some cases, where long sections of the pay formation were to be plugged off, it was found desirable to partially plug back with gravel or cement in order that a smaller quantity of plastic would be required.

The average treatment in the East Texas field has required about 25 gal. of plastic. On a few wells, too much plastic has been used with the result that the entire pay formation has been sealed off. The production on most of these wells was restored by merely drilling out a portion of the plastic, however, occasionally it also has been necessary to shoot the open formation with a gun perforator after drilling out to the desired total depth. On no well has the formation been plugged to such an extent that drilling and perforating would not restore production.

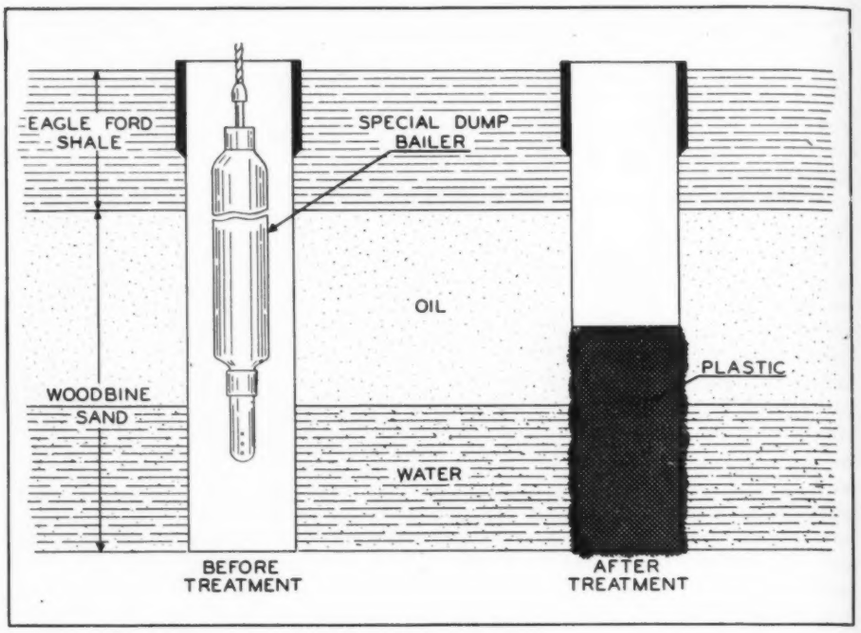


Fig. 4. Conditions before and after a plastic plug job on a typical East Texas well

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Convenient Transmission Belt Calculations

by W. F. Schaphorst

THE formula that is probably used more than any other in belt transmission calculations has the figure 33,000 in the denominator or may be replaced by 0.0000303 in the numerator. Or, make it 0.00003 and there will be virtually no difference in the answer unless the amount of power transmitted is considerable.

The simplified rule is as follows: Subtract the tension in the slack side of the belt in pounds from the tension in the tight side, multiply the difference by the speed of the belt in feet per minute, and then multiply by 0.0000303. The answer will be the horsepower transmitted by the belt.

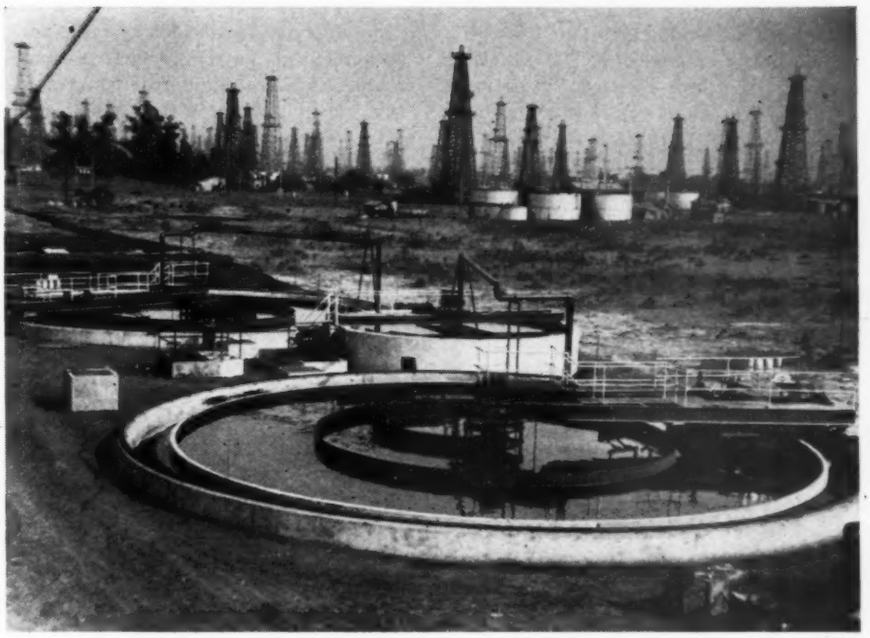
For example, if the tension in the tight side is 300 lb. and in the slack side 100 lb.; and the speed of the belt is 5000 ft. per min., 30.3 hp. are being transmitted. Use 0.00003 instead of 0.0000303 and the answer is 30 hp., an inaccuracy of only 1 percent.

A rule for quarter-turn belt drives that the writer considers superior to the old ones, which do not take all factors into consideration, is given below. This rule applies to high grade 2-ply leather belting.

Add the diameters of the two pulleys in inches, multiply by 2, and then multiply by the cube root of the width of the belt in inches. The result is the minimum distance between shaft centers in inches.

To be sure, judgment must be used in the application of this rule, which is true of most of the rules that are offered for belt transmission. Thus to be safe one prominent manufacturer advises "centers not less than 25 ft." for quarter-turn drives. That is a good rule to keep in mind, but, obviously, it is greater than necessary for narrow belts and small pulleys. If the diameter of the driving pulley is 12 in., the diameter of the follower pulley is 10 in., and the width of belt 3 in., this rule requires that the center distance should be at least 64 in.

When driving a vertical shaft the weight of the belt itself is often a hinderance to a comfortable distance between centers. The belt is inclined to sag on the vertical pulley and it is often advisable to lower the pulley on the vertical shaft ⅛ in. for each foot of center-to-center distance. Also, a light belt is preferable. Do not use an idler pulley unless absolutely necessary. By careful design an idler pulley usually can be avoided. ☆ ☆ ☆



The two continuously-cleaned filter units with flocculating compartments in center. Electric motors move the platforms over the basins to clean the magnetite filter of one unit while the other unit is in service. Santa Fe Springs Waste Water Disposal plant

PETROLEUM ENGINEER Exclusive Feature

Waste Water Disposal In Los Angeles Basin

Some wells are served by central separating plants; in other areas the water is disposed of locally

by Wallace A. Sawdon,

Pacific Coast and Foreign Editor

ALTHOUGH there are several projects under consideration for injection of salt water produced with oil into the producing zone for pressure maintenance, all waste water from oil wells in California at the present time is either taken care of locally or is transported to separating plants for treatment and disposal. In the Los Angeles Basin alone waste water produced in a number of the fields has been so great and of such character that separating plants have had to be constructed to prepare the water for unharmful disposition. The first of these plants was built in 1927 to handle the waste waters from the Signal Hill field. The second was constructed in Orange County and collected waters from the Brea, Olinda, and Richfield fields. These plants consist essentially of subsidence basins, the clarified water being piped to a flood control channel where it enters a bay in the first case and to a county outfall sewer that discharges into the Pacific Ocean in the second.

The third, and largest, plant was first constructed in 1929 to take care of waters from the Santa Fe Springs, Whittier, and Montebello fields and its outfall to serve the West Coyote field. Since its erection, this plant, because its clarified water empties into an inlet from the ocean, has been redesigned and developed to meet changing governmental requirements and is now one of the most efficient plants in existence for treating oil field waste water.

The Santa Fe Springs plant is operated by the Santa Fe Springs Waste Water Disposal Company. The project is non-profit making and operating expenses are met by the companies sending their waste water to the plant for disposal. The volume of water from each participating company is determined by numerous measuring devices, mostly recording weirs, and the quantities so measured are used for allocating the costs of collecting, treating, and disposal. The present capacity of the plant is 100,000 bbl. per day. The clarified water is, of course, checked daily and is kept to specified analysis.

The waste water into the plant contains oil, salt, minerals, bacteria, and mud. The oil content of the water received at the treating plant is approximately 0.1 per cent by volume or 100 bbl. per day. This oil is sold as a low grade crude. The salt content is about one-third of that found in sea water and would thus be detrimental to crops and fresh water supply if allowed to percolate into the subsurface fresh water strata from which the larger part of the domestic and irrigation water is obtained. Other mineral content is high. In addition to sulphate splitting bacteria, which thrive in water as warm as that being produced with the oil, there are chemicals and mercaptans from refining plants that also send waste water to the treating plant.

This water is quite difficult to treat. It has a high specific gravity and the suspended particles of algae and clay are oil-coated. These conditions retard sub-

sidence. The water coming into the plant is warm and the bacterial activity is so great that long periods of retention in tanks and basins result in excessive production of the products of biological degradation, particularly hydrogen sulphide. All these factors were considered in designing the plant, which, as now in operation, eliminates a subsidence period of considerable length.

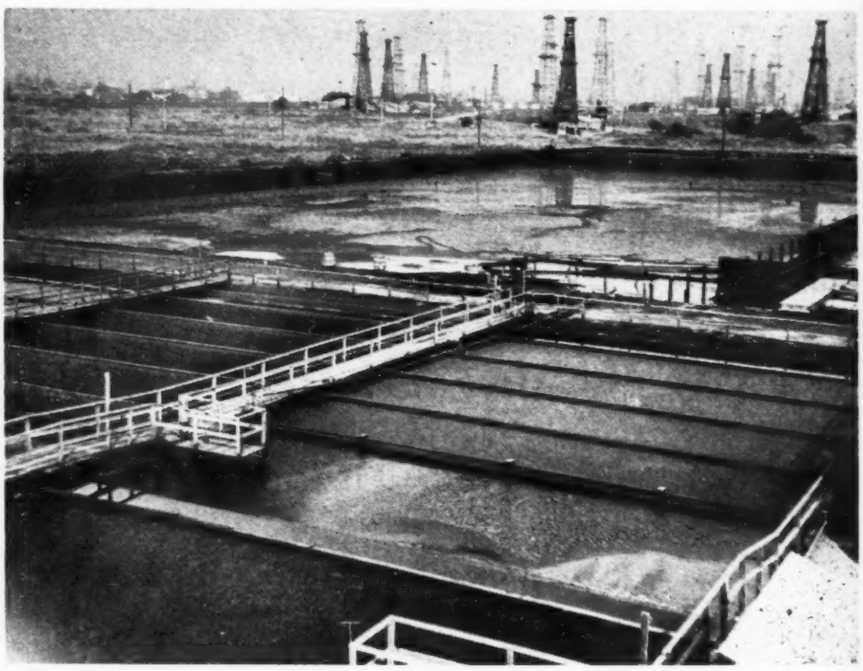
Considerable difficulty is experienced in maintaining and operating the lines carrying water to the plant. This is due to the high mineral content of the waste water from the wells and its tendency to form a hard and resistant scale within the pipe lines. This scale will frequently stop up a line completely in from 6 to 12 months and, because of the many collecting lines, frequent cleaning of lines is necessary. The cleaning of scale from the inside of the lines is done by means of a "go-devil," (a hard cutting screw), which is inserted in the pipe on the end of a jointed rod line made of piano wire metal and rotated as it is forced through the pipe by a motor mounted on wheels, as shown in accompanying illustrations. Clean out openings are provided at regular distances along the main collecting lines and the cleaning out is done without interrupting service. The extent to which pipe and fittings are clogged by scale deposits is also illustrated. The cleaning of the pipe lines is done efficiently and economically by the Flexible Underground Pipe Cleaning Company of Los Angeles.

Separating Plant

The treating plant at Santa Fe Springs consists chiefly of an aeration tower, subsidence basins, automatic chemical treating units, flocculating chambers, and continuously cleaned magnetite filters. Before the magnetite filters were installed the water passed through a compartment filled with excelsior and from there to an asphaltum-lined, concrete basin approximately 4 acres in area for final subsidence and skimming. This large basin is no longer necessary and the water from the filters goes to an outfall leading to a tidal slough and salt marshes.

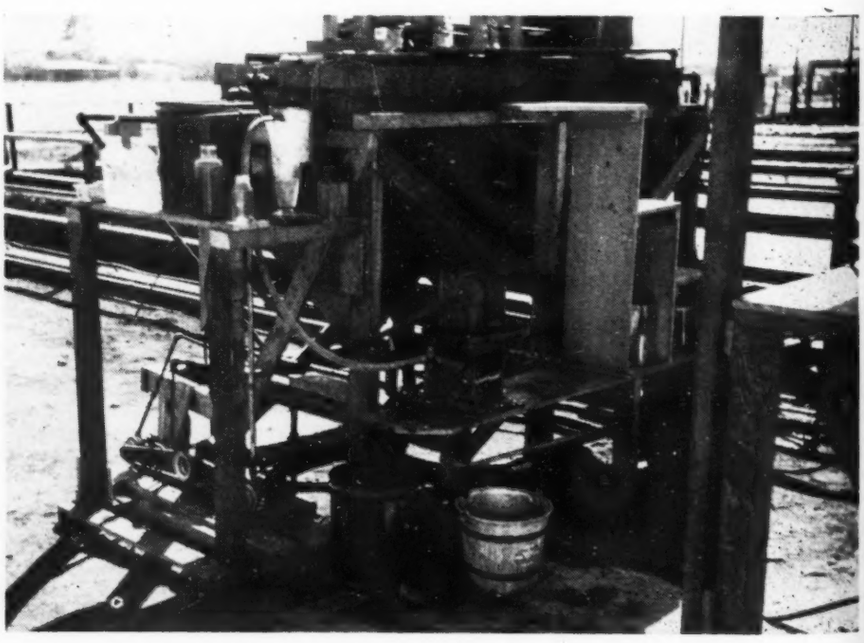
The present plant was developed by means of extensive research work and the results obtained by building several pilot plants of various design. The studies conducted for several years were for the purpose of determining the relative efficiencies of various types of treatment and the economical phases involved. Particular emphasis was placed on treating the effluent from the secondary subsidence ponds and most of the experimental work was carried on from that point. Because of the factors involved, many of which were peculiar to the water treated at the Santa Fe Springs plant, it was found that the magnetite filters offered the most practicable and economical solution and that a small amount of flocculation greatly increased the efficiency of the filter beds. It was then necessary to design a full-sized plant. The experimental runs indicated the advisability of incorporating the following factors in the design of this plant:

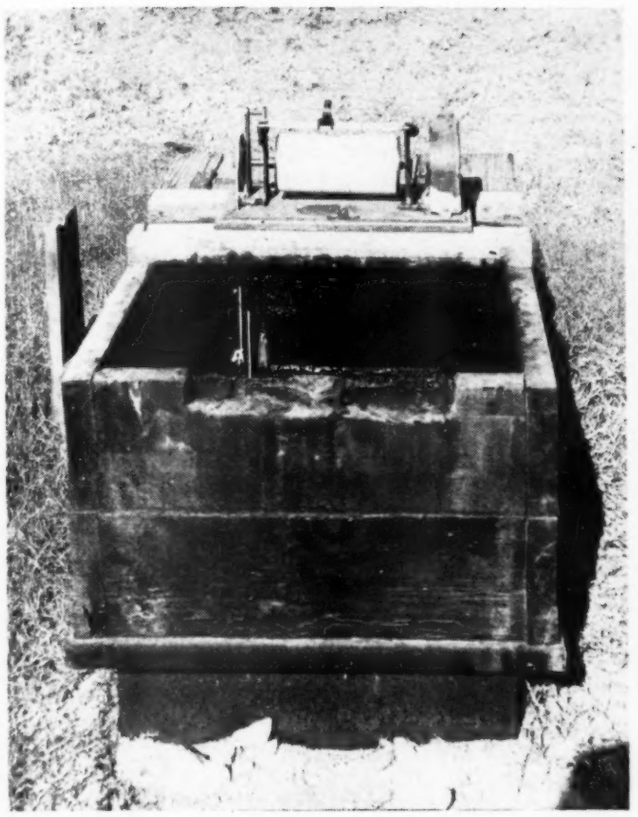
1. Construction of two units for flexibility, safety, and ease of maintenance.
2. Flocculation of influent from 20 to 40 min.
3. Use of aluminum sulphate at approximately 15 p.p.m. to perform suitable flocculation. To this quantity is added acidified sodium silicate to hasten, toughen, and give weight to the floc.
4. Avoid agitation, excess velocity,



Above—Looking over the subsidence units at the Santa Fe Springs plant. Only the end of the primary chamber is shown; beyond it is the secondary chamber. The unit on the right is in service and the one in the middle is being cleaned. Beyond can be seen the large subsidence and skimming basin no longer used.

Below—One of the many pilot plants used to procure data for design of the present plant





Left—This type of weir equipped with recording device is used to measure the volume of water. Right—Cleaning scale from the inside of a waste water pipe line. The rod, driven by motor, rotates a go-devil as it is forced through the pipe

or any disturbance that would break the floc form.

5. Maximum capacity of magnetite should not exceed 2 gal. per sq. ft. per min. Lower rates are desirable.

The waste water into the plant, flowing by gravity from some leases and pumped from others, flows into a distribution channel on top of the aeration tower, passing along this flume and spilling from it over aerating louvers. From the aeration tower the water enters settling chambers where much of the mud drops out and the more easily separated oil floats and is skimmed off, the mud being removed when the chamber is out of service. The oil blanket is confined to this chamber by baffles and the underflow enters the primary subsidence chamber.

The subsidence chambers consist of three units, each 50 ft. by 150 ft. in area and each comprising a primary and secondary basin in series. One of the three units is always empty for cleaning, each being taken out of service in rotation as the cleaned unit is put back into use. The primary basin is 12 ft. deep and the secondary basin 8 ft. As the water flows across the primary chamber the floating oil is stopped by successive baffles and is taken off the surface of the water by flowing into funnel-like scuppers placed near the baffles. The material settling in the bottom is pumped off.

The partially clarified water receives additional aeration as it spills from the effluent end of the primary chamber into the secondary chamber. This chamber is also baffled and a second stage of subsidence occurs. After flowing across this basin the water, further clarified, enters a flume that carries it to one of two circular flocculating chambers. (See illustrations). While passing through this flume chemicals (mainly aluminum sulphate and acidified sodium silicate) are added to cause flocculation, which assists the filter in taking out the finely suspended matter.

The introduction of chemicals is entirely automatic. Water from the subsidence chambers is metered and the volume as measured regulates the introduction of chemicals at a predetermined number of parts per million into the stream. The flocculating compartments are in the center of two circular basins over each of which revolves a platform supporting the cleaning mechanism for the filter.

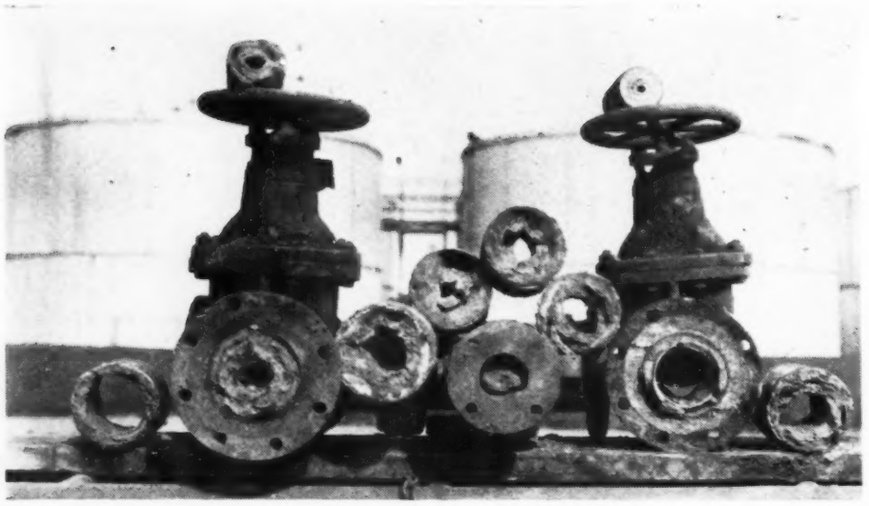
After the liquid has been flocculated it passes to the magnetite filter, which surrounds the flocculating compartment of the circular chamber. The filter bed is but 3 in. in depth and rests on a brass screen base that permits passage of the fully clarified water through it and into the outfall line.

Cleaning of the magnetite filter material is done automatically by the revolving apparatus, one filter being cleaned at a time. The magnetite is a magnetic iron ore and electro-magnets or solenoids attached to the revolving platform lift and drop this material as they pass over it. Agitation of the fluid washes the magnetite while suspended by the magnets. After the filter is cleaned the dirty backwash water remaining in the filter compartment is pumped through the vertical pipe and swing joint to the circular basin situated between the filter-flocculation basins where it is pretreated before being put back into the stream for filtering.

Periodic sample analyses are made throughout the day and night of water leaving the plant. This water is clear in color and contains only a trace of oil. Among the specifications met are the following:

Turbidity—50 p.p.m. or less
H_2S—1 p.p.m. or less
Odor—none objectionable.

The original outfall line was constructed of 14 in. to 24 in. vitrified clay pipe with joints made of asphaltum. Because of the hot wastes then passing through the line the asphaltum joints lost their resiliency and leached out,



The extent to which fittings and lines are clogged with scale is shown here

allowing the pipe to settle and leak badly when the line was running full. Considerable expense was required to make the joints fight. When additional capacity was necessary in 1936 another vitrified clay pipe line, 16 in. to 36 in. diam., was laid parallel to the old line and was jointed with an acid-resistant compound known as Penchlor cement. The material has proved satisfactory and both lines are now in continuous service.

Maintenance of the outfall lines, which are approximately 15 miles in length, is, of course, necessary. The combined capacity of the two lines when clean is approximately 140,000 bbl. per day and when this declines to 100,000 bbl. per day cleaning of one of the lines is begun. It has been found that each line has to be cleaned about once every two years so one line is cleaned every year. Tons of hard, resistant, carbonate incrustations are removed during this operation. Many manholes of vitrified clay brick with acid-resistant joints and protected cast-iron manhole covers have been constructed to solve the problem of oxidized sulphide gas. The original line has been rebuilt when necessary and the entire outfall system now has an acid-resistant interior surface.

Production Cost

The disposal of waste waters from oil fields is a necessary but costly operation, which is a part of the cost of producing the oil. The oil companies have invested approximately $900,000 on the Santa Fe Springs plant and are spending approximately $75,000 a year to operate it. The Long Beach-Signal Hill plant has cost probably $400,000 to date and the plant in Orange County represents an investment of $300,000. This is in the Los Angeles Basin alone and does not include the money spent by the companies in handling locally the waste water from fields in the Basin that are not served by separating plants. The necessary handling of waste water from individual wells is probably more expensive and certainly more troublesome than piping the water to a central plant where it can be handled more efficiently. As fields grow older the conditions become worse; there is more water for disposal. The injection of salt water into producing sands may thus aid in relieving the disposal problem as well as increasing the ultimate yield from the reservoir.

The plant operation is under the direct supervision of Walter Humphreys, manager of the Santa Fe Springs Waste Water Disposal Company, who is responsible for the extensive research work, pilot plants, and design of the operating plant and system that is now operating with a high degree of efficiency.

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Canol Project Draws Barrage of Opinions

When the Senate Truman committee turned investigation upon the Canol project a multitude of voices spoke, bearing on the military, economic and political aspects of the project to build oil production, a refinery, and a pipe line in northwest Canada to provide oil for use in Alaska. Some of the words ran:

"It never would have been undertaken if we had had anything to say about it. We might as well save the $30,000,000 it is estimated it will cost to complete it. It's not sound business judgment to buy something that is worth nothing and will have no value after the war in order to benefit the Imperial Oil Company and the Canadian government."

—Petroleum Administrator Harold L. Ickes.

"Even though the Canol project seems doomed to disappointment, I applaud the army's motive in trying to get oil to fight this war. Price Administrator Prentiss Brown and Stabilization Director Fred Vinson played politics with the oil situation until the army must have become disgusted."

—H. P. Nichols, executive vice president, East Texas Oil Association.

"I think most of the committee is convinced that the project has little or no military value in view of the fact that it won't be in operation before next spring, and the alternative of moving oil from the United States by water would have been faster and cheaper."

—Senator Truman of Missouri, chairman senate war investigating committee.

"Results so far have surpassed our hopes. We uncovered a rich continental source of oil, far beyond the original target of 3000 bbl. a day. Twenty thousand bbl. a day is now assured. We have already uncovered an estimated pool of 50,000,000 to 100,000,000 bbl."

—Undersecretary of War Robert P. Patterson.

"Should the Norman Wells field turn out to be one of the biggest pools on the North American continent, as has been predicted by some oil interests, it will relieve the war department from one of its most embarrassing scandals."

—Peter Edson, columnist, Tulsa (Okla.) Tribune.

"Little is given out as to details (about Norman Wells), but the oil production figures tell a story—23,664 bbl. in 1941, 62,324 in 1943, and 89,929 in the first six months of 1943."

—*Petroleum Times*, London, England.

"The Undersecretary of War . . . has said that Canol may well be the inspiration for other ventures in foreign countries. I am willing to let the case rest on that. If all the crowd of government officials who now have the itch to get into the oil business abroad will use Canol as the justification for their ambitions, I think all of them can be stopped before they spend much money."

—Representative Leon H. Gavin, Pennsylvania.

Modern Direct-Fired Tubular Oil Heater

☆ Fundamental principles of design, and development in light of present-day problems

PETROLEUM ENGINEER Exclusive Feature

PART 1

by R. G. Lovell

Development Engineer, Hancock Oil Company of California

EARLY development stages of the direct-fired tubular oil heater were discussed by the writer in a previous article.[1] It is the purpose of this article to point out how lessons learned in the past are now being applied to the problem.

Much of the previous article on heaters was devoted to a discussion of the fact that progress in refinery processing beyond the heater was imposing new demands upon the heating unit itself, not necessarily confined to greater efficiency, either in the combustion of the fuel or in the transfer of the heat of combustion to oil in the tubes. Necessity in the form of realization that much of the stock, both liquid and gaseous, previously used as fuel for the heaters and considered as of little value for market or for reprocessing, now has been found to have high value for processing into vital new products, has forced us into a radically changed evaluation of furnace efficiency.

It is also obvious that these new and valuable products, because of their rigid chemical and physical specifications, have forced us to a new concept of processing accuracy. The necessity for closer fractionation has again demonstrated the traditionally maternal ability that has always been associated with any necessity. Out of the need for closer fractionation has come, to the writer, the conviction that our previous fractionating technique has been, and is, distinctly inadequate. Because fuel and power costs were low we have been adding enough heat to a unit volume of oil to separate from it all the overhead products required, then have reversed the procedure by subtracting enough heat to permit separation of the overheads by end boiling points. Cuts were made close enough to satisfy specifications simply by using enough heat, a sufficient number of trays, adequate steam, and enormous amounts of reflux and cooling mediums. It is now generally realized that we can no longer afford such methods and it is further conceived that we must take greater advantage of the many manifolding possibilities offered by the continuous-coil direct-fired heater.

This article will, therefore, discuss the problem from two distinct angles: First, burning the fuel with best practicable combustion efficiency; second, transfer of the heat of this combustion to bodies of oil in tubes with highest practicable thermal efficiency and utility.

Principles of Combustion

The fundamental theory of combustion is entirely chemical but its application, insofar as the refinery operator is concerned, is mechanical. If combustion is thought of simply as oxidation or rusting it will clarify one's conception considerably. A piece of iron left exposed to the weather for some period of time will turn into iron oxide, the length of the period depending on the materials in the iron, the temperature of the air, and the nature and percentage of moisture in the air. In this sense, oxidation is a slow process, but measurable for all that. Measurable because the iron oxide weighs less than the parent iron. The loss in weight represents the mechanical work done in the transformation and is a measure of the heat generated in the process.

In the case of combustion of refinery fuels—compounds of carbon and hydrogen—we seek to accelerate the process. To do this requires that the three essentials to fire be supplied: (1) Oxygen laden air; (2) ignition temperature, and (3) adequate and continuous supply of fuel.

Means for distributing to the best advantage the usable products of combustion over the areas to be heated and facilities for disposal of the non-usable combustion products must also be provided. The latter two duties, however, are not functions only of the furnace. They must be considered as a compound function of fuel combustion and heat absorption.

Air and Combustion

The physical introduction of oxygen into the presence of the fuel in such manner as to assure complete oxidation, and at the same time assure the utilization of the greater part both of the oxygen and the fuel, is the most important and difficult problem in the burning of all fuels. The source of supply of the oxygen necessary for combustion is atmospheric air, which may be considered as composed of 23.15 percent by weight of oxygen with the remainder, 76.85 percent nitrogen and other inert gases. For all practical purposes the inert part can be called nitrogen. Therefore, to supply 1 lb. of oxygen for combustion it will be necessary to supply $\frac{1}{0.2315} = 4.32$ lb. of air, and that in this weight of air there will be 3.32 lb. of nitrogen that serves no useful function in combustion. The chemical com-

(Continued on Page 62)

TABLE I

Volume and weight of air at atmospheric pressure

Temperature °F.	Volume, one lb. cu. ft.	Weight per cu. ft., lb.	Temperature °F.	Volume, one lb. cu. ft.	Weight per cu. ft. lb.
32	12.390	0.080710	140	15.111	0.066177
50	12.843	0.077863	150	15.363	0.065092
55	12.969	0.077107	160	15.615	0.064041
60	13.095	0.076365	170	15.867	0.063024
65	13.221	0.075637	180	16.119	0.062039
70	13.347	0.074973	190	16.371	0.061084
75	13.473	0.074223	200	16.623	0.060158
80	13.599	0.073535	250	17.883	0.055919
85	13.725	0.072860	300	19.143	0.052238
90	13.851	0.072197	400	21.663	0.046162
95	13.977	0.071546	500	24.184	0.041350
100	14.103	0.070907	600	26.704	0.037448
110	14.355	0.069662	700	29.224	0.034219
120	14.607	0.068460	800	31.744	0.031502
130	14.859	0.067299	900	34.264	0.029200

[1] "Tube Heater-Fractionating Tower Combination," by R. G. Lovell, *The Petroleum Engineer*, September, 1943, page 140.

An Engineer's Dream

How a simple five-year plan literally *gave* an oil company its own gas-electric power plant

At Fittstown, Oklahoma, an oil company pumps its wells with power from its own electric plant, installed in 1936-37. Generators are driven by seven 8-cylinder, 400 hp Cooper-Bessemer engines, fueled by gas from the company's own wells.

Before the plant was built, a 5-year pay-out plan was set up. This program was improved upon in actual operation. Cost of the plant was only $110.65 per KW capacity, against an estimated $120.00. Figuring otherwise wasted fuel at 8c per thousand feet, the average cost of energy at the busses has been only 2.1 mills per kwh. This compares to 7 mills, the best quotation on purchased energy. How the amortization plan worked out is shown in the chart opposite.

In the face of steadily rising operating costs, many other producers may be figuring on generating their own power. Efficient, reliable Cooper-Bessemer gas engines are ideal for the job, enabling you to capitalize to the fullest extent on otherwise waste fuel. And they are fully convertible to Diesel, should that become desirable.

Write for the 12-page booklet "The Profitable Operation of an Oil Field Electric Plant." It gives the complete history of the Fittstown operation.

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Mount Vernon, Ohio — Grove City, Pa.
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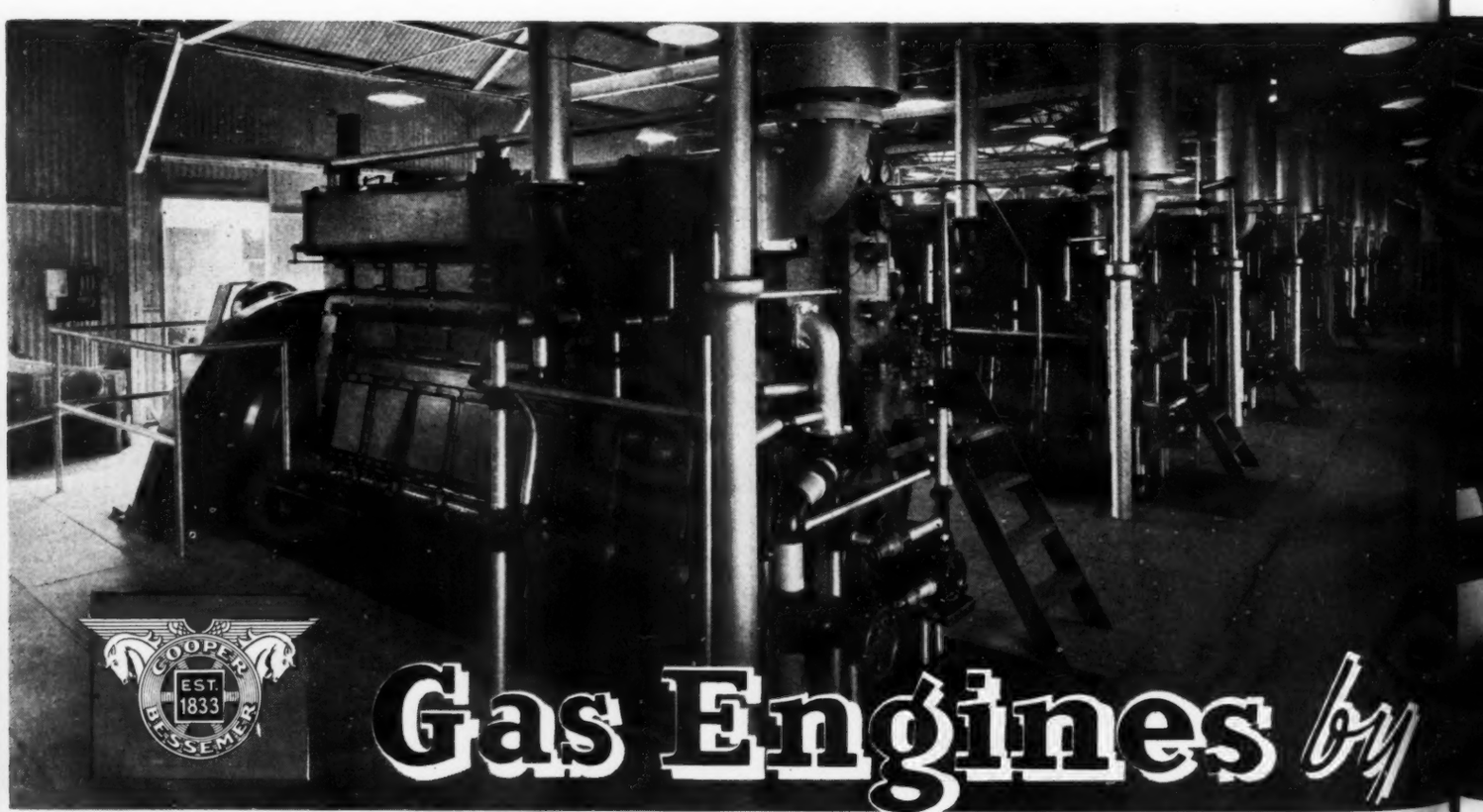
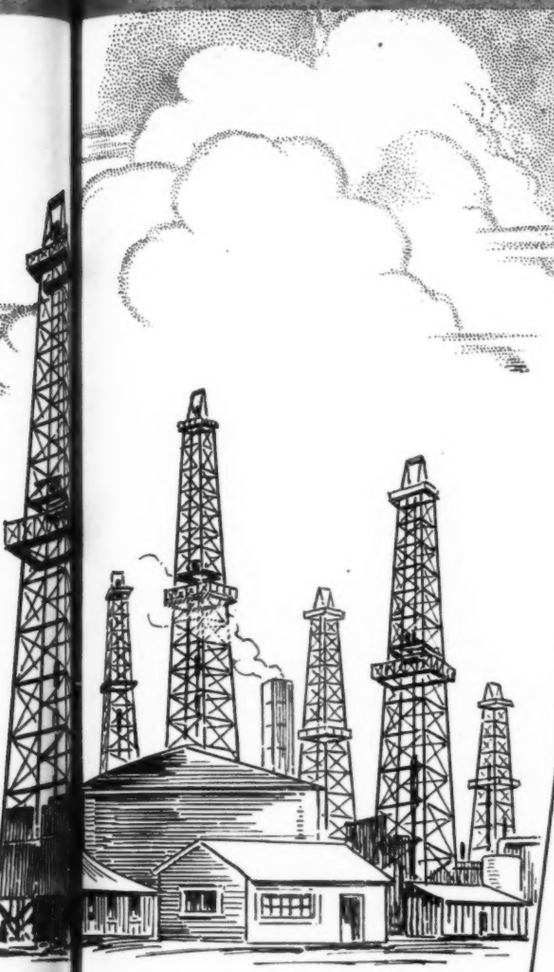


Gas Engines by

BUILDERS OF DEPENDABLE

n Come True!

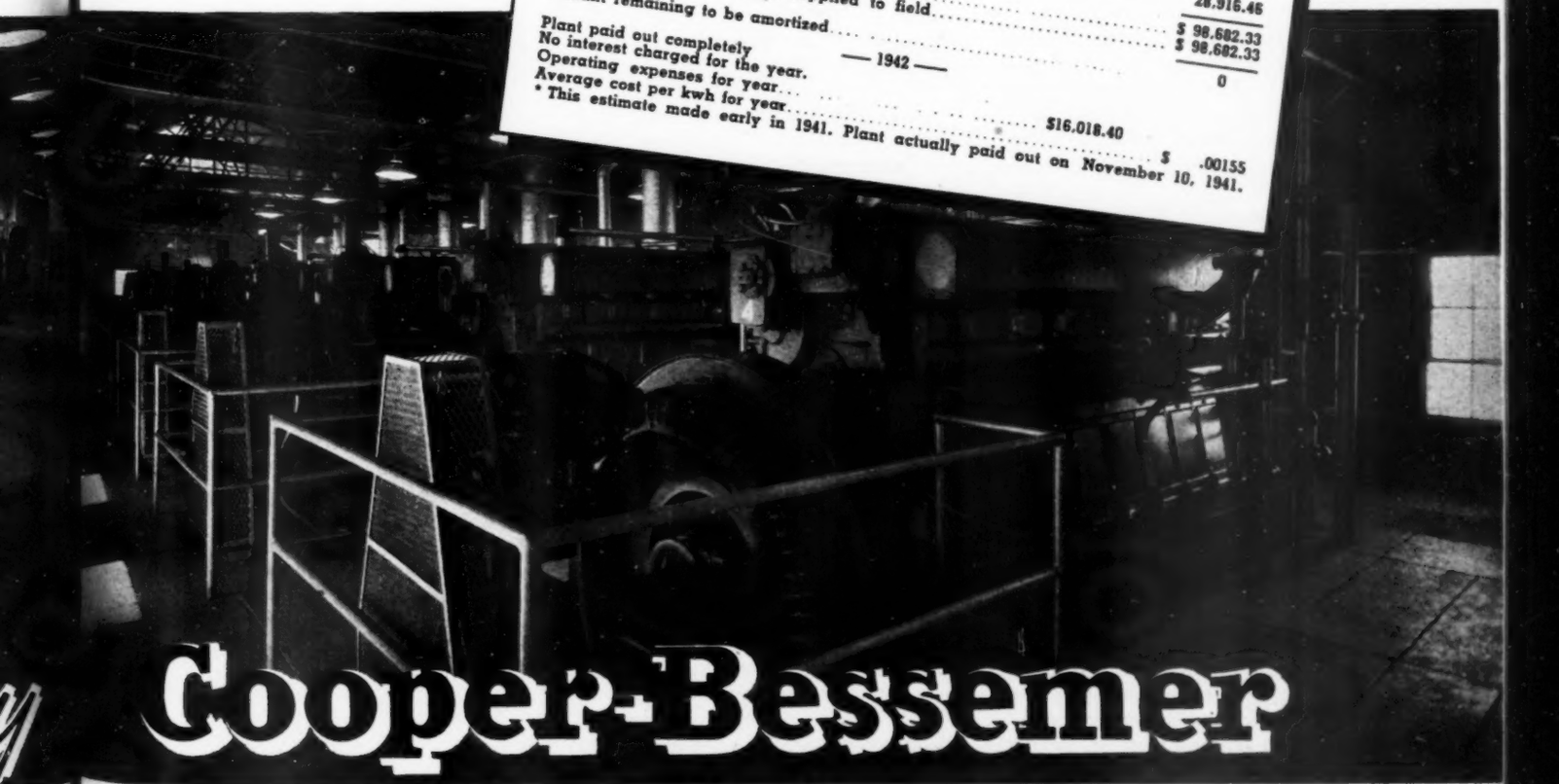


PAY-OUT OF FIVE YEAR PLAN

Fittstown Plant — Formerly E. H. Moore, Inc.
(Now operated by Garrett Logan, Trustee)

Average investment during year	— 1937 —		$125,000.00
Interest at 4%		$ 5,000.00	
Operating expenses for year		17,554.64	
Amount to be paid at end of the year			22,554.64
Calculated value of energy supplied to field			$147,554.64
Amount remaining to be amortized			39,025.51
Amount brought forward from 1937	— 1938 —		$108,529.13
Cost of additional equipment purchased			$108,529.13
Interest at 4%			164,640.92
Operating expenses for year		Total	$273,170.05
		$10,926.80	
Amount to be paid at end of year		24,211.91	
Calculated value of energy supplied to field			35,138.71
Amount remaining to be amortized			$308,308.76
Amount brought forward from 1938	— 1939 —		82,173.64
Credit for 1 unit transferred and 2 sold			$226,135.12
Interest at 4%			$226,135.12
Operating expenses for year			47,777.78
		Remainder	$178,357.34
Amount to be paid at end of year		$ 7,134.17	
Calculated value of energy supplied to field		24,921.28	
Amount remaining to be amortized			32,055.45
Amount brought forward from 1939	— 1940 —		$210,412.79
Interest at 4%			79,980.40
Operating expenses for year			$130,432.39
Amount to be paid at end of year		$ 5,217.30	$130,432.39
Calculated value of energy supplied to field		26,125.82	
Amount remaining to be amortized			31,343.12
Amount brought forward from 1940	— 1941 —		$161,775.51
Interest at 4% for year			92,009.64
*Operating expenses for year			$ 69,765.87
Amount to be paid at end of year		$ 2,790.64	$ 69,765.87
*Estimated value of energy supplied to field		26,125.82	
Amount remaining to be amortized			28,916.46
			$ 98,682.33
Plant paid out completely	— 1942 —		$ 98,682.33
No interest charged for the year.			
Operating expenses for year			0
Average cost per kwh for year		$16,018.40	
			$ .00155

* This estimate made early in 1941. Plant actually paid out on November 10, 1941.



Cooper-Bessemer

ENGINES FOR 110 YEARS

(Continued from Page 59)

binations occurring in the union of oxygen with the combustible elements and compounds ordinarily found in fuels are many but full consideration of them in this article would only be confusing and detract from the primary objective. It should be understood, however, that from the manner of such combinations—and dissociations—and consideration of the atomic weights of the elements involved, the proportionate part by weight of the elements entering into the resulting compounds can be readily computed as well as the weights of the products of combustion. With the amount of oxygen required for combustion thus known the amount of air required for the combustion of a fuel will be indicated from the oxygen-nitrogen ratio existing in air.

For our present simple purpose it will be sufficient to state that 11.52 lb. of air are required for the complete combustion of 1 lb. of carbon, and as each pound of oxygen is accompanied by 3.32 lb. of nitrogen, there will pass off with the carbon dioxide, formed by the combustion of the carbon, 8.85 lb. of nitrogen. Eight lb. of oxygen are required for the complete combustion of 1 lb. of hydrogen, which means, as for the combustion of carbon, $8 \times 4.32 =$ 34.56 lb. of air required to burn 1 lb. of hydrogen. The nitrogen present in this weight of air is $8 \times 3.32 = 26.56$ lb.

To express these amounts of fuel and air in pounds instead of volume units is, of course, meaningless if one were required to measure them on that basis. (Table 1.) It is necessary to express them so because their relative quantities must take into consideration their atomic weights. Further, although the calculations for transforming them into volume units are not particularly difficult, they would necessarily be based on some set of standard conditions of pressure and temperature and this could never be maintained in practice. The one dependable method is to establish the percentages of the products of combustion by analysis of the discarded flue gases. This analysis, however, must be coordinated with an exact analysis of the fuel in use. All this is a study in itself and, although its importance warrants complete explanation, that will be deferred until a later time. We are presently more interested in mixing some hydrocarbons and air, then burning the mixture to the best practical advantage.

To divide the combustion into two operations will aid in the analysis:

First, the mixing of fuel and air.

Second, burning the mixture.

Previous discussion of combustion, as well as combustion practice, assumes these are simply two steps that are to be considered jointly as occurring simultaneously. We contend that this should not be true; that the more completely the two steps are divorced the lower will be the percentage of excess air necessary to use and the consequent nearer approach to perfect combustion and better furnace efficiency. The fundamental reason, of course, for the necessity to use any air in excess of the theoretical amount is that only about 23 percent of atmospheric air is oxygen. The remainder is totally inert as a combustible but can be used as a carrier of heat of combustion either to add to or subtract from the thermal efficiency of the heater —and the choice is largely under control of the user. It may be interesting to note that if the inert elements were not present the temperature of combustion would be much beyond the capacity of any furnace or heater materials to withstand. So we see that some percentage of excess air is necessary. This fundamental reason, for years, has been used by some as an excuse for furnace conditions amounting, in some cases, to several hundred percent excess air.

Oil Outlook — 1944

H. J. STRUTH, petroleum economist, in the January number of *The Petroleum Engineer* will have some unusual observations and conclusions concerning the oil situation in 1943 and the outlook for 1944. Another year of discouraging results in the search for new oil reserves further emphasizes the inequities between oil prices and costs confronting American oil producers. Struth's studies of oil-finding rates and costs, his analysis of the supply and demand picture, present facts that justify higher crude prices—facts that are timely and pertinent to the crisis now confronting the American oil industry.

Corrective Measures

When gas or atomized oil comes into contact with air there is an immediate mixing, the rate of mixing depending chiefly upon how well the oil is atomized or the gas is distributed in the mixing area. How complete the mixture is made is chiefly a function of the amount of air and the time allowed for the mixing. When these are exactly right the result is a highly explosive mixture. If there is too much air and too much time the result is a weak combustible mixture. Understand that the nitrogen mixes in with much the same facility as the oxygen of the air and thereby retards the oxygen mixing.

In the design of many direct-firing refinery oil heaters the area provided for this mixing is so limited that the mixing is far from complete at the time it comes into contact with the high furnace temperature of previous combustion. The inevitable result is that combustion begins long before the mixing is completed whereupon some amount of carbon dioxide and carbon monoxide are formed both of which have the capacity of so diluting the mixture that its ability to absorb oxygen is further reduced and an excess amount of air must be introduced into the combustion chamber in order to complete the combustion. This has been the conventional way of assuring that combustion was complete but the assurance has, in many cases, been taken for more than it was actually worth. For example, many operators have the notion that a high stack temperature indicated the need for greater excess air. This is not, necessarily, a sound conclusion because this excess air, admitted into the combustion chamber instead of into an auxiliary mixing chamber, absorbs heat of combustion more readily than the oil in the tubes and not all of this heat is reabsorbed in the latter passes but manifests itself in high stack temperature. An attempt to lower the stack temperature arbitrarily by admission of additional air may be successful insofar as stack temperature is concerned but is bound to reduce both the thermal efficiency and potential duty of the heater. To endeavor to restore the duty factor by increasing the fires only starts the vicious cycle all over again.

Types of Combustion

There has long existed the fallacy that complete combustion implied close approach to perfect combustion. Such is definitely not the case and it will be well to distinguish here between perfect and complete combustion. Perfect combustion is the result of supplying the requisite amount of oxygen for union with all the oxidizable constituents of the fuel and utilizing in combustion all the oxygen so supplied. Complete combustion, on the other hand, results from the oxidation of all the combustible constituents of the fuel but does not of necessity imply the utilization of all the oxygen supplied. If perfect combustion could be accomplished in the heater furnace there would be no unavoidable combustion losses. Although combustion is complete but not perfect, there are losses due to the supplying of too great an amount of air, and it follows that the more nearly complete combustion can be made to approach perfect combustion, the less will be the loss in burning any fuel. It is this problem—the seeking after perfect combustion—that is the problem of furnace design.

(To Be Continued)

☆ ☆ ☆

Motor Vehicles Propelled By Producer Gas*

☆ **A discussion of the utility of gasogene vehicles and the types employed**

by Gustav Egloff and Prudence Van Arsdell
Universal Oil Products Company

AN index of world conflict might well be reflected in the number of internal-combustion vehicles in use throughout the world that run on producer gas from solid combustibles. An estimate based on many sources gives the number as about 820,000[1] gasogene vehicles in all countries of the world.

Since the second World War began, stern necessity has driven countries to the use of producer gas propelled vehicles in ever increasing numbers because of the lack of petroleum or other types of gasoline substitutes. In 1938 Europe operated about 9000 gasogene busses and trucks, whereas only a few were operated on any other continent. In 1941 about 450,000 vehicles were in operation in all parts of the world; by 1942 approximately 820,000 were in use not only in land vehicles, but also in river boats, barges, and stationary engines. In the United States there are now about one-half dozen producer gas propelled motor vehicles operating experimentally on wood or charcoal. All the gasogene engines operating on producer gas in the world are substituting for more than 25,000,000 bbl. of gasoline a year.

The solid combustibles used as sources of producer gas include wood, wood char, coal (anthracite, brown, bituminous, lignite, and coke), peat, corn cobs, grain wheat, flax waste, coffee husks, nut shells, cotton seed, sugar cane branches, and lignin.

In the last two years or so several countries, such as Australia, Brazil, and Chile, with little or no oil production, have been manufacturing gasogene vehicles. On May 1, 1943, there were 73,650 producer gas vehicles in use in Sweden; these represented 91.5 per cent of all vehicles on the roads, and about 33 per cent of the prewar number. Of these vehicles about 60 per cent operated on charcoal, and the remainder on untreated wood.[2] Australia has more than 45,000, whereas a recent report (June 26, 1943) covering Brazil[3] appeared as follows:

"To aid in overcoming the fuel problem affecting transportation, the Brazilian government recently authorized the importation of material into Sao Paulo to manufacture 11,000 'gasogenios' to be installed in trucks and busses. Busses running between Santos, the coffee port, and Sao Paulo, have shown excellent results. Recent official reports from Brazil indicate that as of April 15 more than 2000 gasogene automobiles were in circulation in Rio de Janeiro, and about 10,000 vehicles equipped with this device were operating in Sao Paulo.

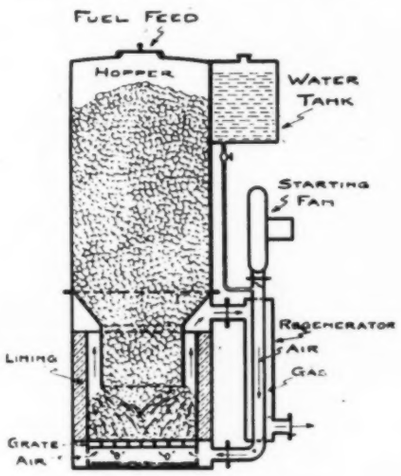


Fig. 1. Up-draught type

"Dozens of installations intended for cars are being sent to farms where they are taking the place of the gasoline engines that formerly created motive power. The gasogenes are also being built for installation on farms to provide economical lighting.

"Two large factories have recently been constructed to manufacture this device, and about 40 gasogenios are built daily. The gasogenios use charcoal, which in combustion creates a gas to propel the vehicle. Some of these charcoal-producer gas units generate 1000 hp.

"So large has become the demand for powered charcoal for these units that a large cement company has turned over one of its mills for the preparation of powdered charcoal for former gasoline service stations.

"Recently, Brazilians witnessed the first gasolineless automobile race ever held in their country. Thirty-two stock cars equipped with gasogenio apparatus competed for the benefit of the Brazilian Red Cross. Vascos Amerios, a Brazilian, driving a United States stock model, won the race with an average speed of 40 miles per hour."

Still later figures show that 22,000 vehicles are now in use in Brazil[4].

As the world conflict increases, many refinements of machinery for gas producers are being made; but along with these have come several major problems in the production of fuel for the engine. These are in order of importance (1) solid fuel shortage; (2) lack of transportation for solid fuels; (3) steel and alloy shortage; (4) lack of equipment manufacturing, and (5) manpower shortage for engine conversion and production of fuels.

The problem of raw material for fuel looms as large for the gasogene vehicle as it does for the gasoline driven engine; and for this reason a sensible question might be, "Why change to the substitutes in the first place?" That, too, is answered by the statement—it is necessary. We who live in the United States, despite our tremendous production of petroleum, have felt the pinch of rationing, even though we are not short of gasoline. We have not yet, however, been deprived of a fairly flexible transportation system. Another point of importance, steel and alloy shortage, has made itself felt in most countries because of the need for military weapons of all kinds.

The manpower shortage is probably the greatest problem we face along with material; for although women make good mechanics and technicians, they are required in great numbers in munitions plants, and the production of the

*Presented before Petroleum Division, American Chemical Society, Pittsburgh, Pennsylvania, September 5-10, 1943.

[1]See Table 1, page 70.

[2]*Petroleum Press Service*, September, 1943.

[3]*Foreign Commerce Weekly*, June 26, 1943.

[4]*Newsweek*, July 26, 1943.

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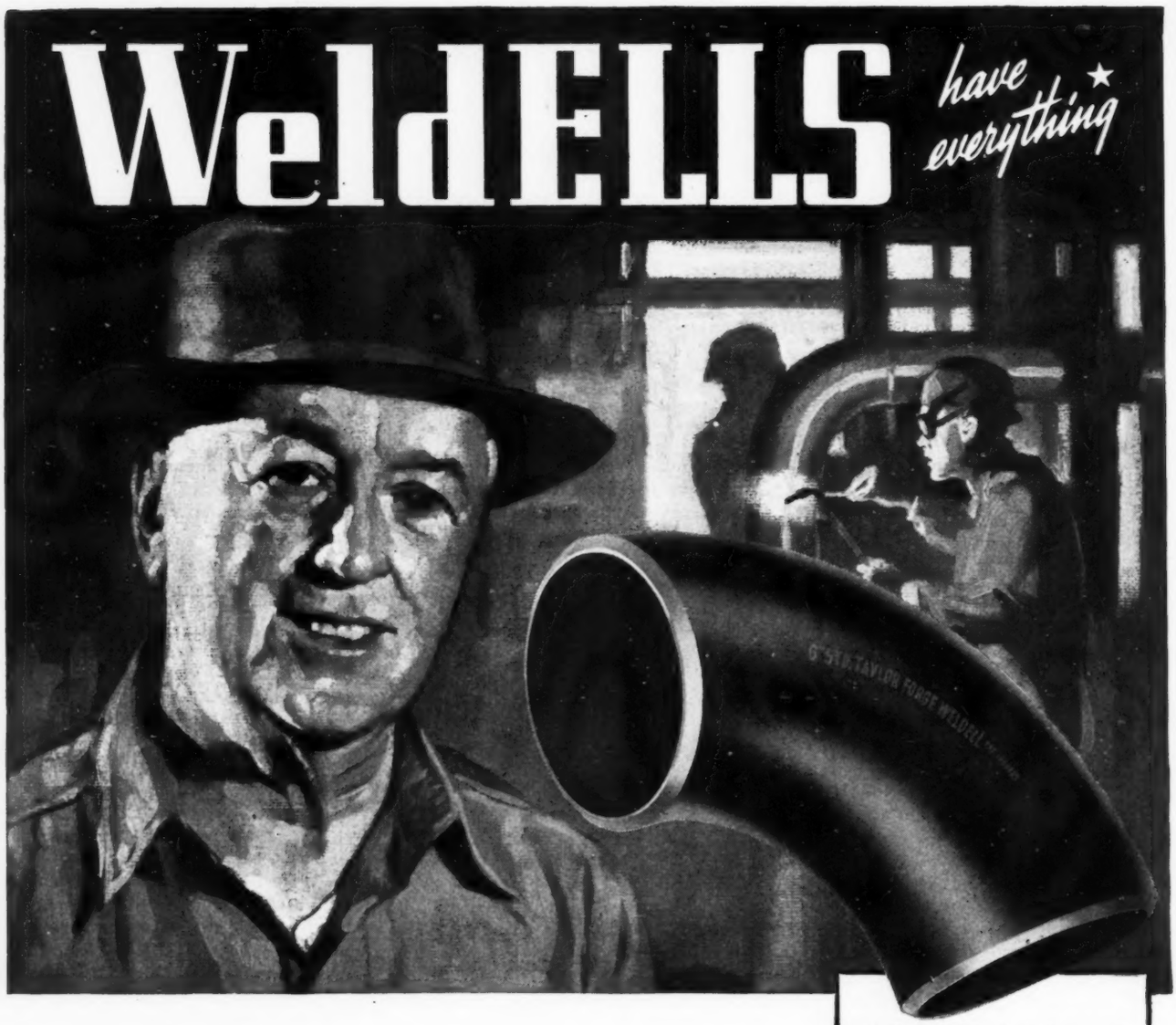

"They're built to give the man on the job a hand!"

FROM the way they pile the work on me these days you'd think my job as foreman of the pipe crew is to put in the piping today that the front office won't finish planning till tomorrow!

The front office crowd might consider that laying it on a little thick. But whatever they think, they will have to admit that we have kept up with their wildest demands and done the job right, too.

Of course the main credit for that goes to fellows who do the work. But down to the last man they would be the first to agree that they couldn't have covered as much ground, or covered it as well, if it hadn't been for their old friend, WeldELLS.

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★ **WeldELLS alone have all these features:**

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- **Wall thickness never less than specification minimum**—assures full strength and long life.
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The list of Taylor Forge's contributions to the war effort only begins with WeldELLS. One of many examples is Taylor Corrugated Marine Furnaces, essential to many merchant ships and transports.

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necessary quantities of raw material for combustibles and for installation of equipment is thereby limited.

Inadequate transportation and lack of equipment manufacturing have increased the problems of producer gas conversion. As a rule, the smaller the country, the more important become these problems, because of the type of prewar economy under which it operated, whether it was a country with a large balance of trade—hence large importation of oil—or whether it depended upon internal production to provide the necessary fuels. France, Germany, and Italy before September, 1939, were striving for national self-sufficiency in motor fuels. After coming under Axis domination, many European countries have had their own individual troubles with producer gas vehicles; and as a rule, the smaller the country in proportion to the number of vehicles running on substitutes, the greater has been the difficulty involved because of scarcity of all factors involved in their production and use.

The Axis-controlled countries have been compelled to adapt their existing essential stationary engines and river boat engines to producer gas operation. In Norway three hundred fishing vessels have been equipped with gas generators.[5] Gasoline consumption in Denmark amounts to only 1 percent of the peacetime rate, nearly all cars now being operated on producer gas. Up to the present time wood charcoal has been used; but coke burners have now been approved, and licenses to install wood burners are no longer issued.[6] Denmark has been experimenting with peat coke in fishing vessels and ferry boats.[7] It is also reported that one large shipping yard has built a motor ship operated by a producer gas fueled diesel engine, which has given satisfactory performance.[8] The entire Dutch fishing fleet has been ordered to use producer gas exclusively, as there is no means whereby liquid fuels can be furnished.[9] After the collapse of France in 1940 this country was cut off from all supplies of liquid motor fuel, and immediate steps were taken to convert motor vehicles to producer gas use. Originally some 400 authorized manufacturers produced 80,000 units of various types within a year. In June, 1941, the manufacture of plants operating on charcoal was prohibited, and resort was made to wood or coal. The types of units and the number of manufacturers have been gradually reduced until there are now 138 manufacturers making 19 types of producer units, 10 using wood and 9 using coal.[10] The use of 40 river boats operating on producer gas in France was reported last year, [11] and large-scale production was projected. France also expected to have 100 stationary engine plants in operation on producer gas by June, 1942,[12] although up to July, 1943, there had been no confirmation of this report. The carrying out of the project, together with the continuing conversion of automobiles, as well as the preparation of solid fuels, has made the completion of the project doubtful, as the French labor shortage even as early as May, 1942, was more than 500,000.[9]

[5] *Petroleum Press Service*, October, 1942.

[6] *Foreign Commerce Weekly*, September 25, 1943.
[7] *Petroleum Times*, June 13, 1942.
[8] *Petroleum Times*, April 3, 1943.
[9] *Petroleum Times*, January 9, 1943.
[10] *Petroleum Times*, September 4, 1943.
[11] *Petroleum Times*, August 8, 1942.
[12] *Foreign Commerce Weekly*, May 30, 1942.

Solid Fuels

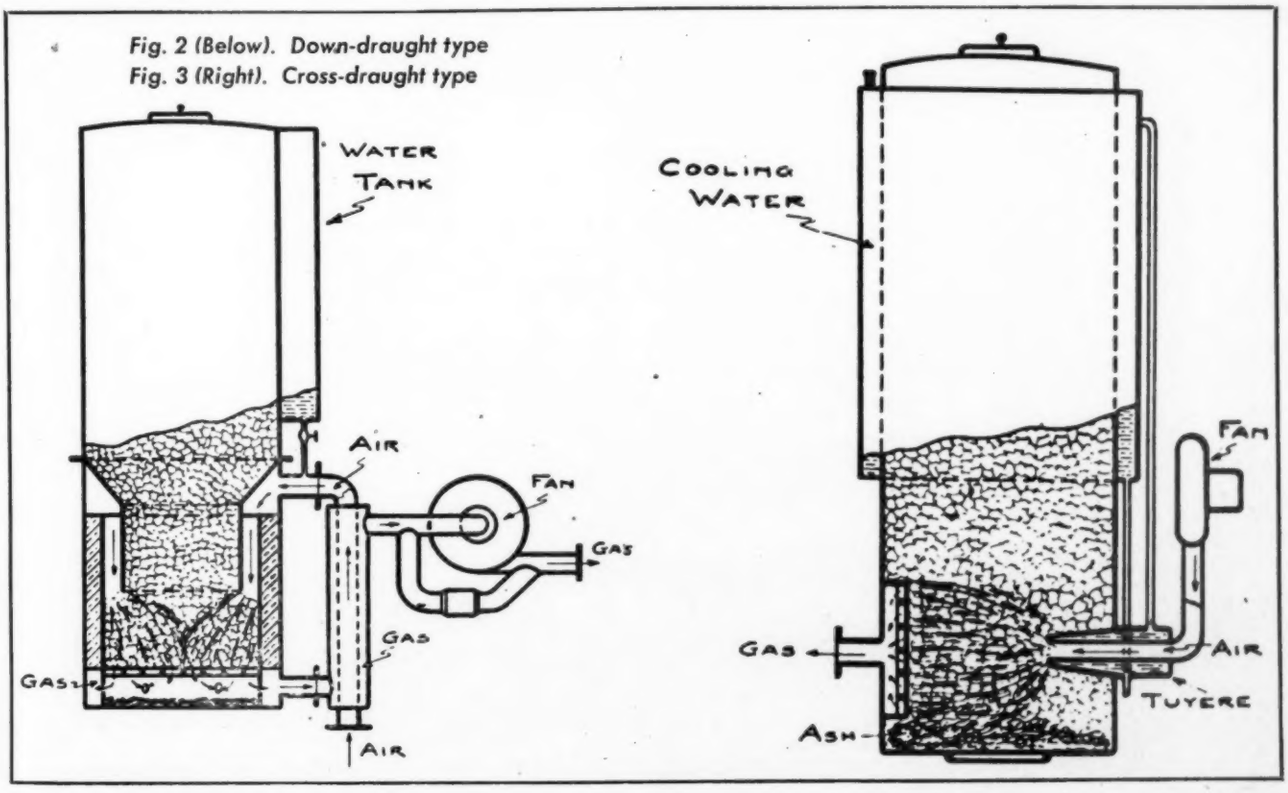
Many solid fuels are being used for producer gas vehicles. Charcoal, wood, and coal have been utilized to a greater extent than all other types. Table 2 shows the fuels used in these gasogene vehicles.

Utilization of all these fuels presents problems not encountered in the gasoline engine. Such fuels as wood and coal deposit tar and acids, presenting problems of cleaning and corrosion of sizable importance when selecting material to be used in constructing the generator. Coal and lignite present problems of clinkering as well as of tar formation. Sawdust does not burn well, and peat does not hold together well for burning. Moreover, all fuels shown must be treated as individual problems for solution in varying types of producer equipment, which must also be carefully considered as to the type of fuel for which it is best suited.

Without exception all early uses to which the producer gas equipment were placed are still applied; in addition, power plants have also been equipped with the gas-generator type of engine,

(Continued on Page 70)

Fig. 2 (Below). Down-draught type
Fig. 3 (Right). Cross-draught type



Compre

...or Plant Operates A MILE AT SEA!

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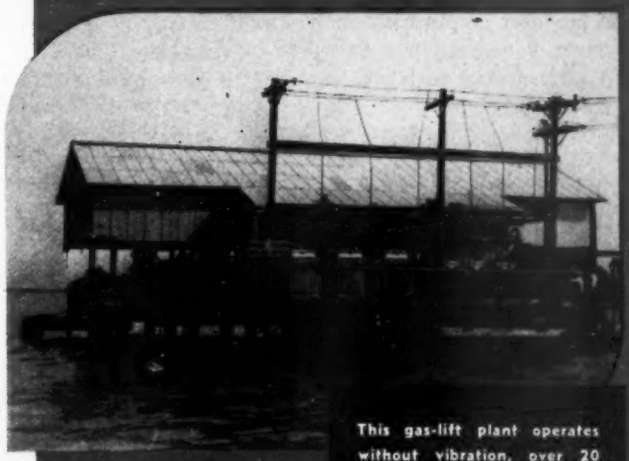
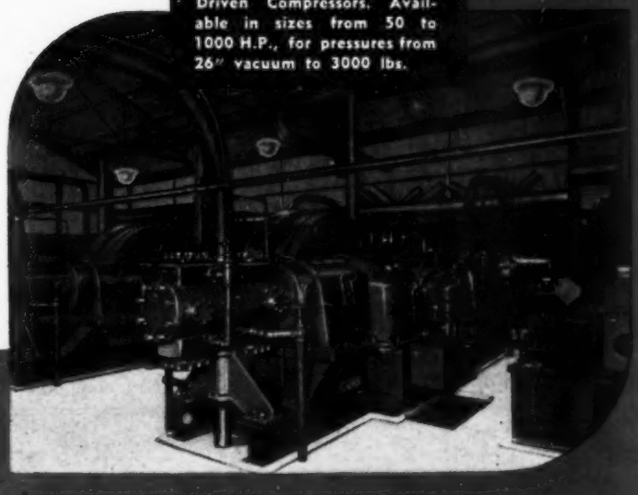
This unit is especially adapted for locations where it is impossible to construct firm, solid foundations. It is widely used for natural gasoline and vapor recovery plants, gas and air lift, refrigeration, and in special process work, for which automatic control of pressures or volume can be readily built in.



This gas-lift plant operates without vibration, over 20 feet of water, atop of piling.



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(Continued from Page 67)

as well as one airplane to run on charcoal[13] and a few low power rail cars.[14] On account of stringency of the liquid fuel situation, the Axis and Axis-controlled countries are compelled to convert as many types of engines as possible to the use of producer gas. Italy has ordered the conversion of her entire fleet of 68,500 agricultural tractors to gasogenes[15] by 1947. Germany has also ordered that all road and farm tractors of 25 hp. and over use producer gas for motive power. In addition, all stationary and ship engines operating on liquid fuels are being converted wherever possible to the use of either producer gas or high or low pressure gas operation. The only types excepted from this order are certain military vehicles, or those vehicles which cannot, for construction reasons, be converted to the use of solid fuels.[16] All new civil and military trucks are being built to utilize producer gas.[17]

Types of Plants

The types of gasogenes generally used fall into four categories:

A. Up-draught.
B. Down-draught.
C. Cross-draught.
D. Double-draught and double-zone.

A producer gas plant as employed for purposes of mobile power includes:

A. A generator with fuel-hopper.
B. Coolers.
C. Filters (to dedust the producer-gas stream).
D. A gas throttle and, in some cases, a starting fan and water regulator.

[13] Anon., *Oil Weekly*, October 12, 1942.
[14] *Foreign Commerce Weekly*, December 12, 1942.
[15] *Petroleum Press Service*, April, 1943.
[16] *Petroleum Times*, October 31, 1942.
[17] *Foreign Commerce Weekly*, January 23, 1943.

Up-Draught Producers

In the up-draught type of producer the flow of air and gas is in an upward direction and countercurrentwise to the fuel flow. From the thermal point of view this method appears to be the best, but for fuels producing tarry substances, the method entails the necessity of providing effective means of preventing tarry matter from reaching the engine. In this type of producer the various zones of chemical reaction are layered horizontally, one above the other. Up-draught producers use low temperature cokes, anthracite, charcoal, and charcoal briquets as fuel. Up-draught producers give gas of better quality than the down-draught or cross-draught types, and are the easiest for starting the engine. Gasification is carried out at moderate velocities, and in most cases steam or water is added to the entering air stream. There is better flexibility with the addition of water, whereas intervals of servicing and cleaning are also longer.[18] Fig. 1 shows the principle upon which an up-draught producer operates.

Down-Draught Producers

In the down-draught type of producer the flow of air and gas is in a downward direction concurrently with the fuel. These units use mainly wood charcoal briquets, raw wood, or coal or mixtures.

Down-draught producers are characterized by their ability to burn the tarry distillates and fuel dust, but they suffer to some extent from uneven thermal balance. Water is not used to any extent with down-draught producers, but certain manufacturers assert that charcoals containing up to 25 per cent moisture can be used with full efficiency.

A cross-section of a down-draught producer is shown in Fig. 2.

[18] B. Goldman and N. Clarke Jones, *J. Inst. Fuel, 12*, 103-140 (1939).

TABLE I

Axis-controlled countries	Maximum number of vehicles reported in use (1942)	
Germany	350,000	(1)
France	110,000	(2)
Italy	35,000	(1)
Denmark	20,000	(1)
Belgium	15,000	(1)
Hungary	6,000	
Norway	3,500	(5)
Holland	1,000	(3)
Slovakia	50	(4)
Total	540,550	
Neutral countries		
Sweden	73,650	(6)
Switzerland	15,000	(1)
Spain	2,200	(7)
Ireland	1,100	(9)
Portugal	450	(8)
Total	92,400	
Allied countries		
Russia	100,000	(15)
Australia	45,000	(10)
Brazil	22,000	(1)
Britain	10,000	(6)
India	10,000	(14)
Chile	1,000	(17) (18)
China	500	(16)
South Africa	100	(11) (12)
Scotland	47	(13)
United States	6	(20)
Canada	1	(19)
Total	188,654	
World total	821,604	

Reference list for Table 1

(1) Newsweek, July 26, 1943.
(2) Petroleum Press Service, Sept., 1942.
(3) Petroleum Press Service, Jan., 1942.
(4) Foreign Commerce Weekly, May 28, 1942.
(5) Oil Weekly, Oct. 12, 1942.
(6) Petroleum Press Service, Sept., 1943.
(7) Petroleum Times, Feb. 20, 1943.
(8) L. J. Logan, Oil Weekly, June 14, 1943.
(9) Petroleum Times, July 12, 1943.
(10) Petroleum Press Service, July, 1943.
(11) Petroleum (London), Aug., 1942.
(12) Foreign Commerce Weekly, May 30, 1942.
(13) Petroleum (London), March, 1943.
(14) Foreign Commerce Weekly, July 17, 1943.
(15) S. Luzerkh, Survey for Petrol. Liter., Oct. 9, 1942.
(16) Petroleum Times, Aug. 8, 1942.
(17) Foreign Commerce Weekly, Feb. 6, 1943.
(18) Petroleum Press Service, May, 1943.
(19) Chicago Tribune, July 18, 1943.
(20) Estimated.

Cross-Draught Producers

In the cross-draught type of producer the flow of air and gas is across the producer though not necessarily in the same horizontal plane. The fuel flow is downward.

The object of this design is to concentrate the combustion and reduction zones into a small space, the fire being,

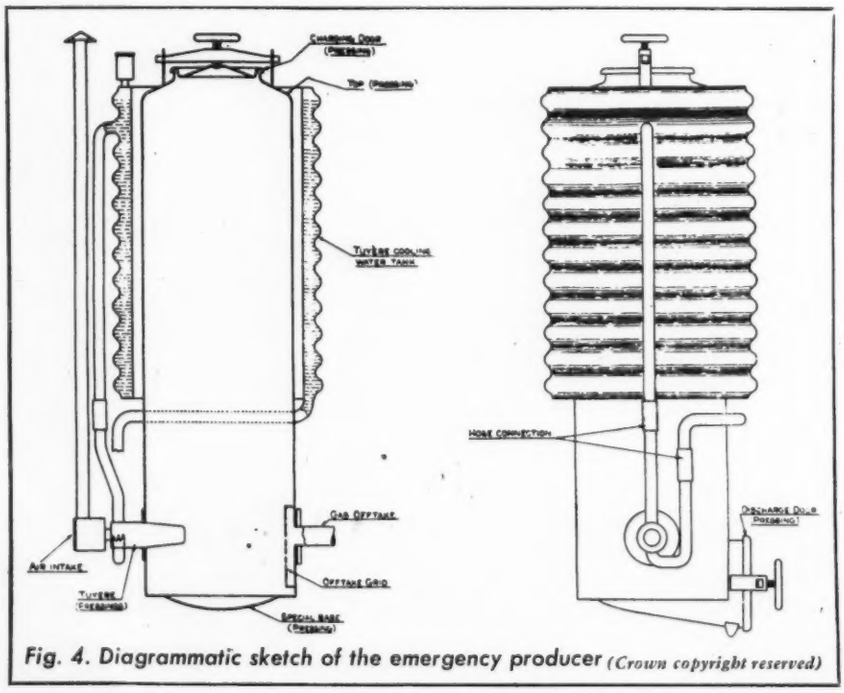


Fig. 4. Diagrammatic sketch of the emergency producer *(Crown copyright reserved)*

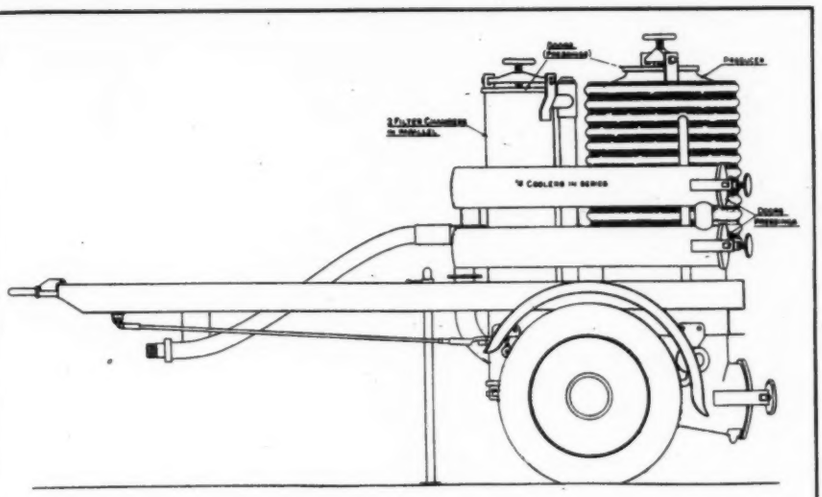


Fig. 5. Diagrammatic sketch of trailer unit showing emergency producer and auxiliary equipment (Crown copyright reserved)

in fact, built up in concentric zones.

In this system gasification is achieved by admitting air at very high velocity into the fuel bed through a narrow water-cooled tube (blast pipe) or tuyere. This results in the development of high temperatures. Temperatures to 2000°C. are claimed in the combustion zone with rapid reaction. These producers are characterized by their simplicity of construction and quick starting of the motor.

Fig. 3 is a section of a cross-draught gas generator.

The cross-draught producer gas equipment was recommended by the Committee on the Emergency Conversion of Motor Vehicles to Producer Gas[19] in Great Britain as a fairly simple expedient in case of wartime blockade, when it would be necessary to change the gasoline automobiles to run on home produced fuels. The committee made a detailed analysis of the project for converting to producer gas equipment. The disadvantages in the use of producer gas were stated to include increased capital and maintenance cost, interference with operating schedules, reduction in pay load, and difficulties in obtaining suitable fuels. In its economic aspect good vehicles might be placed in a higher tax and lower speed category, and the project was stated to be of doubtful economic value except for long hauls with vehicles carrying medium or heavy loads. In France prior to the war the use of producer gas vehicles was encouraged by almost complete remission of taxes. Operating difficulties were experienced through the failure of overheated air inlet lines and of fabric filters when wet fuels were used.

The conclusion of the committee was that attempts should be made to develop the simplest and cheapest form of producer gas equipment adaptable to mass production, in order to promote rapid conversion from gasoline to producer gas if emergency necessitated it. The possibility of designing a single type of producer suitable for all classes of vehicles was considered.

The general arrangement of the recommended producer is shown in Figs. 4 and 5.

The emergency producer consists merely of a thin steel cylindrical shell, approximately 4 ft. 6 in. high and 1 ft. 6 in. in diameter, fitted with a fuel charging door at the top, and ash discharging door at the base, and air intake or tuyere, and a gas offtake protected by a detachable grid. The tuyere is water-cooled, the heat from the cooling water being dissipated from an annular radiator tank fitted round the upper part of the producer shell.

TABLE 2

Wood

1. Charcoal
2. Wood (green or dried)
3. Sawdust
4. Shavings
5. Chips
6. Waste
7. "Generator"
8. Wet

Coal

1. Brown
2. Lignite
3. Anthracite
4. Coke (low temperature)
5. Coke (high temperature)
6. Coke (Breeze briquet)

Peat

1. Peat (dried)
2. Peat (carbonized)
3. Peat coke
4. Peat (briquet)

Miscellaneous

1. Corn cobs
2. Flax waste
3. Lignin
4. Grain wheat
5. Coffee husks
6. Nut shells
7. Cotton seed
8. Sugar cane (branches)
9. Grape seeds
10. Straw

The number of parts has been reduced to a minimum; for example, no use is made of water injection, and there is no clinker removing apparatus. The plant is built throughout of mild steel plate, which is relatively cheap, and no special metals or complicated processes are employed in its manufacture. Even the tuyere, the correct functioning of which is of vital importance, is of simple design and contructed of mild steel.

For ease of production in quantity, the maximum use is made of pressings, including the tuyere, and the top and the base of the shell. The doors also are simple pressings, and are interchangeable not only between themselves but also, as will be seen later, with those on the auxiliary apparatus. It will be noted that by the use of the special base interchangeability of the top and bottom doors is not procured at the expense of ease of cleaning.

The use of the annular radiator tank makes the unit self-contained and independent of the engine cooling system. This is of importance for ease and cheapness of fitting the producer, either in the lorry itself or on a trailer unit. Incidentally it makes the system more foolproof.

Road tests have shown that the performance of this producer equipment is satisfactory in service using low volatile anthracite and certain types of low temperature coke. This result has been obtained by careful choice of dimensions, and attention to detail, including the elimination of non-essentials, and not by the sacrifice of any desirable feature.

Coolers and Filters

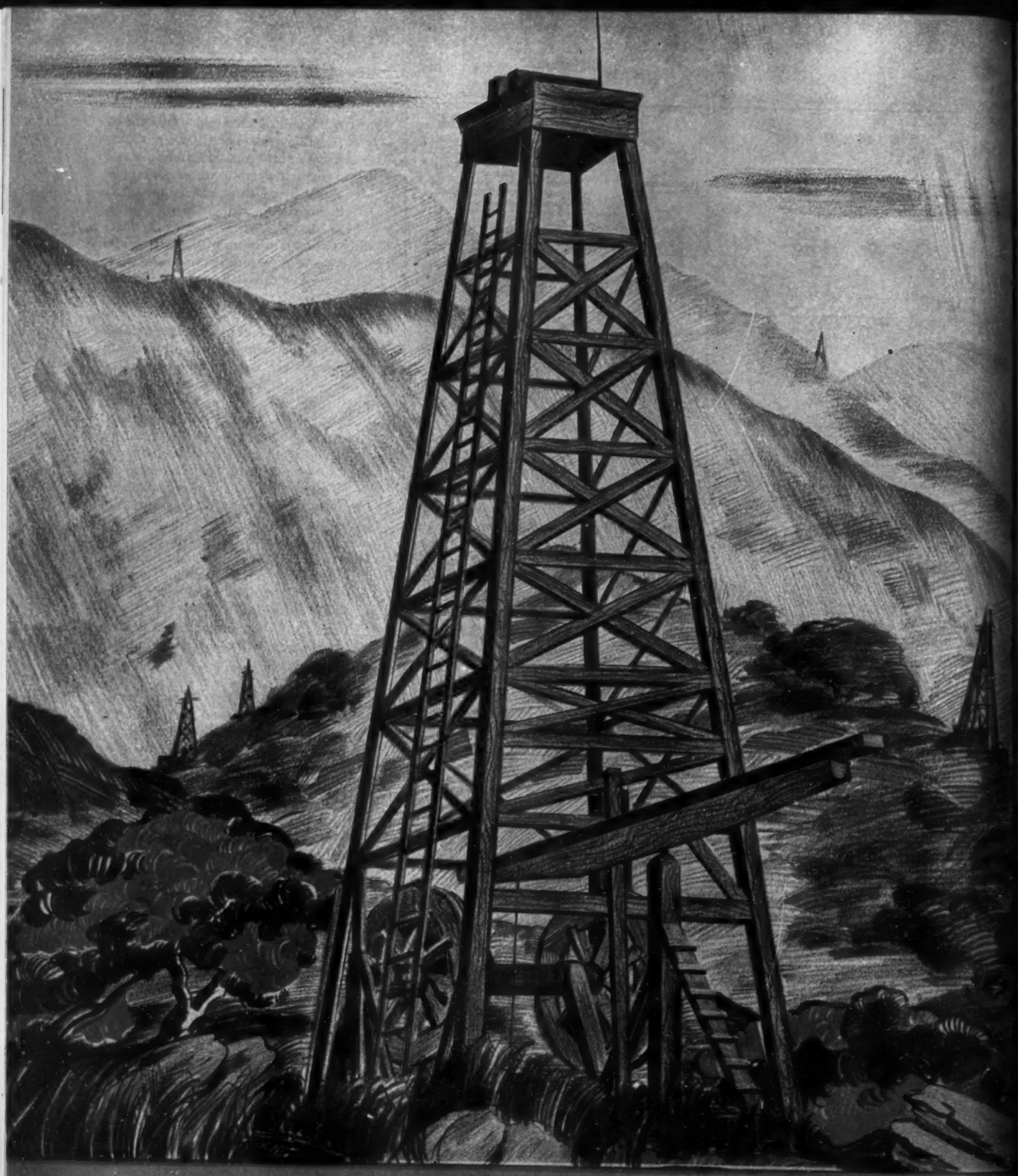
In the committee's design of equipment for mounting on a trailer, the gas leaving the producer passes in series through four cylindrical coolers, each about 3 ft. 6 in. long and 6 in. in diameter, arranged two on either side of the chassis. Doors made from mild steel pressings are fitted for cleaning.

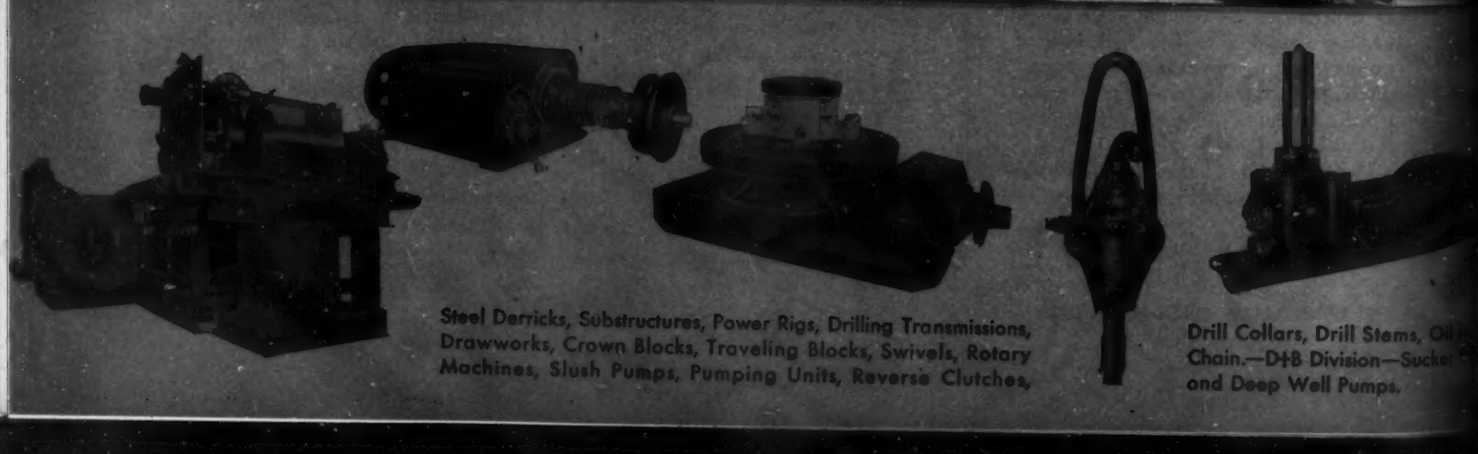
In the model shown (in Fig. 5) the cooled gas passes through a filtering unit consisting of two vertical cylinders, fitted with doors that are interchangeable with those on the producer. The filter is so arranged that the gas passes in parallel through four beds of sisal tow, which is used as a filtering medium. An alternative design of filter may, however, be used. From the filter, the gas is led through a quickly detachable flexible coupling to a pipe on the lorry, leading to the engine.

EDITOR'S NOTE: This article will be continued in an early issue.

☆ ☆ ☆

[19]Report of the Committee on the Emergency Conversion of Motor Vehicles to Producer Gas, Great Britain (1939).





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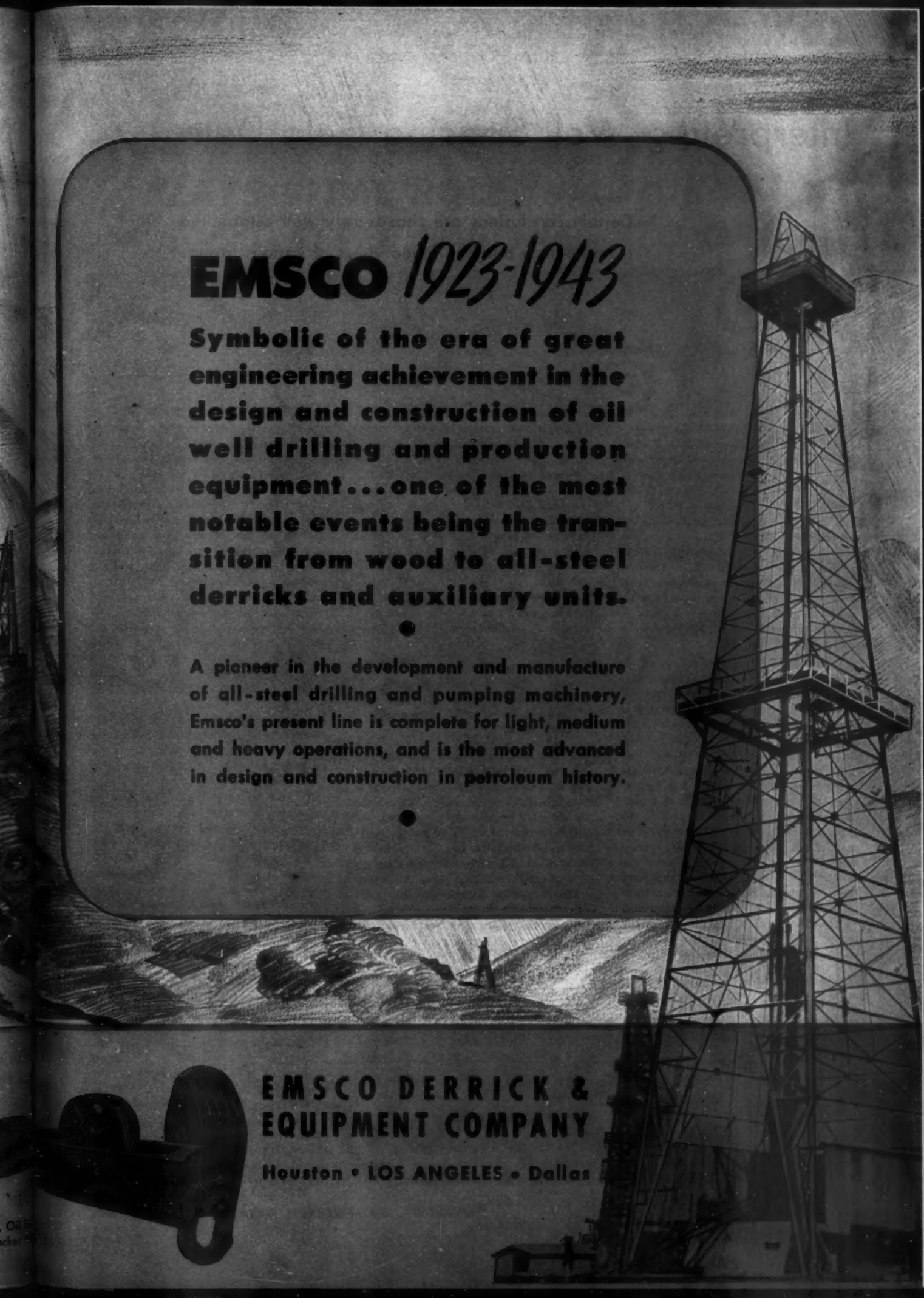
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Interpreting Well Spacing Field Data

Exclusive Feature

☆ Certain conclusions are reasonably well established from findings and expressed views of various groups

by Lester C. Uren

Professor of Petroleum Engineering, University of California

THE two preceding articles of this series,[1] reviewing recent progress toward understanding of the well spacing problem, have been concerned with the physical and economic factors involved. These variables constitute the fundamental criteria upon which any approach to a scientific analysis of the problem of well spacing must be based. It will next be of interest to review the results of various field studies and observations that appear in the literature on this subject, which will perhaps assist us in deciding upon the actual influence and practical importance of the various factors involved.

In interpreting the field data, authorities seem to be divided into two groups, one of which believes that close spacing of wells increases ultimate recovery, whereas the other group believes that wide spacing of wells ultimately produces as much, if not more oil, than close spacing. Members of the former group generally base their conclusions upon data procured in fields in which expanding gas has provided most of the expulsive energy and with little or no restriction. Members of the latter group have been concerned largely with the more recently developed fields that have been restricted by proration requirements and in many cases these have been "water drive" fields. The position of the latter group is seemingly reinforced by the results of recent laboratory studies.

Close Spacing

Perhaps the first authoritative engineering study of the influence of well spacing on production efficiency, was that by W. W. Cutler[6*] of the U. S. Bureau of Mines, results of which were first published in 1921. Cutler assembled data from the Bartlesville Sand producing areas of northern Oklahoma and from the Butler County fields of Pennsylvania, comparing oil recoveries obtained with different well spacings. Table I presents data typical of that gathered by Cutler in the fields of Nowata County, Oklahoma. It will be observed that in each group of properties where initial productions are comparable, closer spacing yielded the larger ultimate production per acre, but wider spacing gave larger ultimate production per well.

Cutler's theorem. Analysis of the data suggested a relationship that Cutler expressed as follows:[7]

> "The ultimate productions for wells of equal size in the same pool, where there is interference, seem approximately to vary directly as the square roots of the areas drained by the wells."

This is equivalent to saying that the recovery will be inversely proportional to the distance that the oil must travel to reach the well; that is, if we double the distance between wells we procure only half as much oil. This assumes utilization of the same amount of energy in each case. "Interference," according to Cutler, is indicated by a difference in the producing decline rates for wells differently spaced; that is, closely spaced wells decline more rapidly than widely spaced wells if they are within drainage influence of each other.

Cutler's rule may be expressed in the form of an equation;[24] thus, $P_w = C\sqrt{A}$, where P_w is the ultimate production of the well in barrels, A is the area drained by the well, and C is a constant for a given reservoir. If we accept this rule, it follows that $P_a = \frac{C}{\sqrt{A}}$ where P_a is the ultimate production of oil per acre.

The validity of Cutler's rule has been questioned by many authorities during recent years, though it seemingly has the support of field data, at least in certain types of reservoirs and within a certain range of spacing. Cutler himself expressed doubt concerning the universal applicability of such a rule, and indeed subsequent studies have shown that in some fields it obviously does not apply. Simple mathematical inspection will show that the rule leads to absurd conclusions, when applied to situations where very close spacing of wells is assumed. For example, it may be reasoned that if wells 400 ft. apart recover 40 percent of the recoverable oil, reducing the spacing of the wells to 200 ft. will result in recovery of 80 percent of the oil, and wells 100 ft. apart will recover 160 percent.[21] The rule is, of course, not applicable in fields where edgewater encroachment is providing the energy that expels the oil. It cannot be expected to apply in areas where the producing formations are highly lenticular or are faulted, or where other discontinuities exist.

If the pressure loss of oil flowing through a reservoir rock is expressed by Darcy's equation, it is clear that the assumption that recoveries are proportional to the distance between wells is untrue. It can be shown, for example, that by applying the Darcy equation for radial flow into a well only 10 percent more energy is required to move oil through a reservoir rock over a distance of 660 ft. to the well than is required to move it at the same rate through 330 ft. of the same reservoir rock.[24]

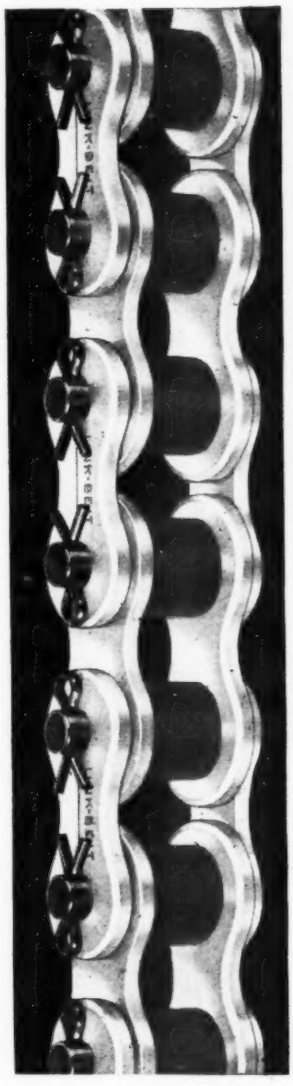
Although we must reject the Cutler theorem as one of broad, general application, yet it must be admitted that the field evidence submitted by Cutler in support of it is impressive. It is undoubtedly true that for certain types of reservoirs where the reservoir rock is a sand or sandstone of approximately uniform thickness, porosity, and permeability, where gas energy latent within the oil is the dominant expulsive force, and where wells are allowed to produce

[1]Earlier articles of this series were printed in the September and November, 1943, issues of *The Petroleum Engineer*.

*Superior figures refer to similarly numbered items in the bibliography published in the September, 1943, issue of *The Petroleum Engineer*, P. 126.

Silverlink ROLLER CHAIN

PLAYS VITAL ROLE IN "COOKING" STEEL CASTINGS "TO ORDER"



Above: Silverlink roller chain (1¼" pitch RC-100), on cut tooth sprockets, serves to open and close the covers of 11 hardening and draw furnaces in the new TESCO heat treating plant. Power is supplied by a hydraulic drive. Silverlink roller chain (1½" pitch RC-120), also drives the transfer car to and from loading and unloading points, and the furnace cars to and from furnaces. Power for these cars is supplied through Link-Belt herringbone speed reducers and Friction Fighter roller bearings.

● Texas Electric Steel Castings Company, specialists in oil industry equipment castings, recently began operations in their new million-dollar heat treating plant, which is equipped with 11 vertical type and four car type furnaces fired by natural gas. Temperature, ranging from 1150 to 1800° F., is observed, controlled and recorded from a remote point through use of the most modern, electrically operated control system.

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ROLLER CHAINS

TABLE I

Ultimate productions for wells of different spacing in the Nowata District, Bartlesville Sand Fields, Oklahoma

(After W. W. Cutler, Jr.[6])

Spacing, acres per well	Initial year's production	Ultimate production per well, bbl.	Ratio of ultimate per well productions	Ultimate production per acre, bbl.	Ratio of ultimate per acre productions
10	6,000	16,900	100	1,690	100
8	6,000	15,200	90	1,900	112
6.3	6,000	14,300	84.5	2,386	141
10	4,000	12,200	100	1,220	100
8	4,000	10,900	89	1,366	112
6.3	4,000	10,300	84.5	1,717	141
10	2,000	6,900	100	690	100
8	2,000	6,100	88.5	766	111
6.3	2,000	5,700	82.5	950	138

without restriction, the rule seemingly applies within the range of well spacing commonly employed in comparatively shallow fields.

Haseman[12] and Phelps[27] have evolved mathematical formulae based on the Cutler theorem and other assumed relationships, but these too must be rejected as applicable only under certain conditions. Furthermore, these as well as other well spacing formulae thus far advanced, require in their application the assumption of values for different variables that are difficult to estimate with any degree of accuracy. They assume knowledge of factors that can only be known after the field is depleted, or at least well advanced in its development, useful perhaps in "post-mortems"; but what is needed is a formula that will permit of predicting proper spacing in advance of development. When one considers the many factors involved and the complexity of the problem, it seems doubtful that we can ever hope to evolve an all-inclusive and generally-applicable well spacing formula.

Early studies of field data to determine the influence of well spacing on ultimate recovery ignored the fact, since made apparent, that in many fields fluids are capable of moving through the reservoir rocks over wide areas. One may not assume that a well or a group of wells is capable of draining only a restricted area in the immediate vicinity. Theoretically, and in some degree practically, each well has its influence on the performance of every other well producing from the same reservoir. Thus, a group of closely spaced wells allowed to produce freely in one part of a productive area, creates a locality of reduced reservoir pressure in their vicinity, which results in oil and gas from surrounding areas flowing toward them through the intervening reservoir rock. By "regional drainage," as this has been called, widely spaced wells in the surrounding areas lose some of the oil within their immediate sphere of influence to nearby, more closely spaced groups of wells. Thus, when we compare the results of close and wide spacing on the basis of performance of groups of wells of varying spacing, we are apt to conclude that close spacing offers an advantage in increased ultimate recovery, whereas the advantage would not exist if the field were developed with uniformly spaced, simultaneously drilled wells.

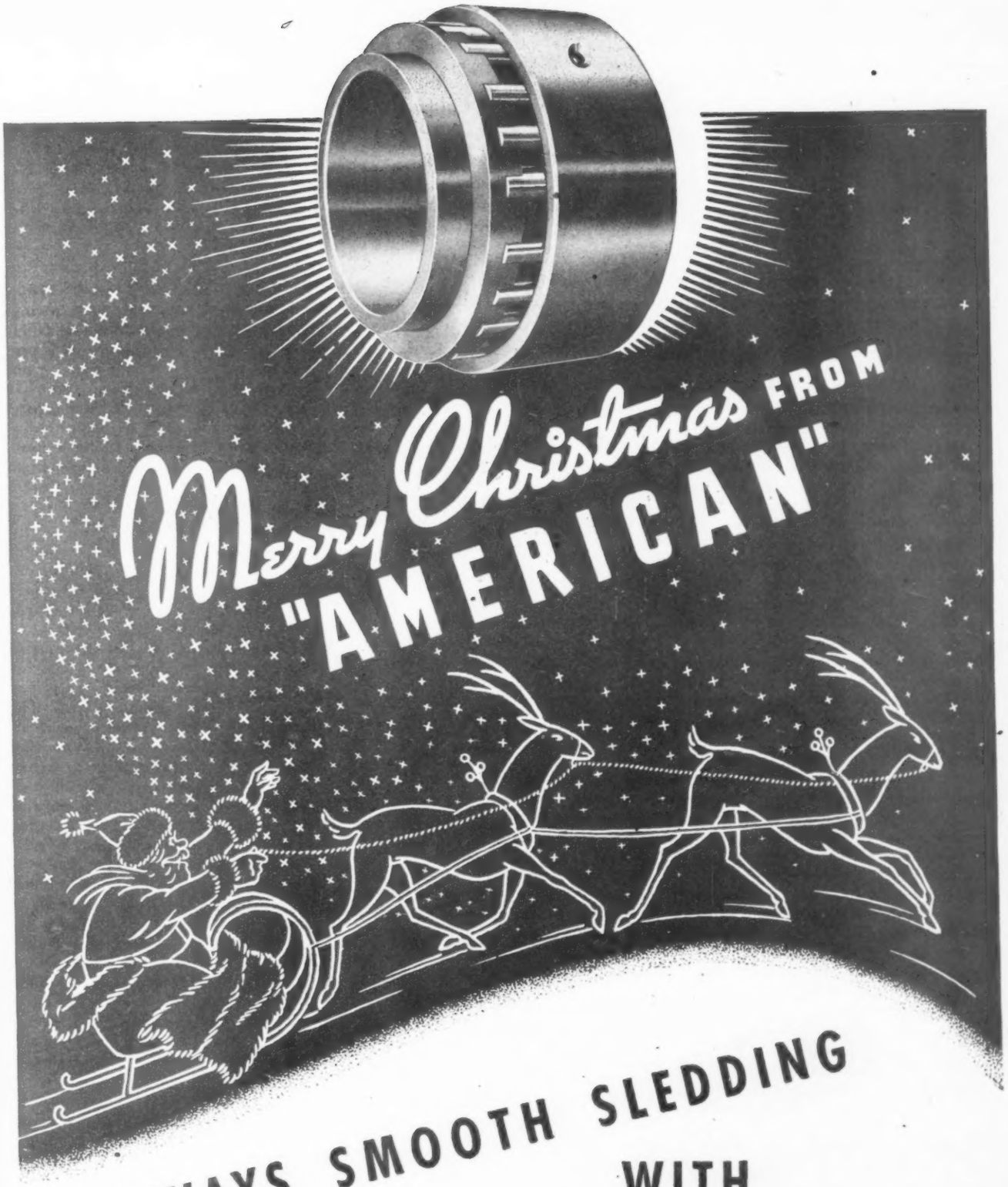
Examples of this are found in studies made of the influence of well spacing on ultimate recovery in the Long Beach[32] and Santa Fe Springs[13] fields of California. (See Tables 2 and 3). These are "town lot" fields, producing from great thickness of semi-consolidated sands. All wells are closely spaced in terms of average practice, and yields are high. In these studies, offset or contiguous areas were chosen, in one of which wells were closely spaced whereas in the other the wells were more widely spaced. Wells in each of the groups compared produced from approximately the same thickness of sand in the same stratigraphic horizon and were concurrently developed. From inspection of the data thus assembled, it is concluded that, "in no case has the recovery per acre in widely spaced areas reached the recovery obtained in closely drilled areas. The difference between them is greatest during early life when wells are flowing in flush production, and tends to decrease during later years. Yields per well during early life are about the same, irrespective of the spacing, giving much greater recovery per acre for closely spaced wells during this period."

S. F. Shaw[34] has analyzed the conditions presented in the Oklahoma City field on the basis of various assumptions of recovery, costs, and prices, based on actual field results. The Wilcox zone in this field, comprising 4000 acres, supports 550 producing wells, or an average spacing of about 7.3 acres per well. The ultimate recovery will approximate 50,000 bbl. per acre. Shaw states that most operators believe that recovery would be reduced with a smaller number of wells and assumes in his calculations that 10-acre spacing would have yielded 40,000 bbl. per acre and 40-acre spacing, 20,000 bbl. per acre. Gas energy has produced most of the oil, but edgewater is active in some areas. It is estimated that 72,000 bbl. per acre or 55 percent of the original oil content of the Wilcox sand has been recovered in one quarter section where wells have been closely spaced (3 acres per well). Computations based on average drilling and production costs and various assumed selling prices for crude petroleum, indicate that little profit will be made by the average Wilcox zone well in this field with restricted production and oil selling at $1 per bbl. Under these conditions, 40-acre spacing shows a slightly greater ultimate profit than 7¼-acre spacing; but with oil selling at $1.50 per bbl. or better, 7¼-acre spacing is substantially more profitable. Shaw expresses the opinion that restricted production in this field has resulted in excessive gas wastage and loss in ultimate recovery.

U. S. Bureau of Mines engineers have gathered data bearing on the influence of well spacing on ultimate recovery in many Mid-Continent and Gulf Coast fields. On plotting recoveries in barrels per acre-foot of sand as ordinates against spacing in acres as abscissas for groups of properties that have been operated substantially to economic depletion under open flow methods and where the producing reservoir rocks are similar in character, it is found that the resulting curves trend downward with decreasing slope in the direction of wider spacing. That is, such curves are concave upward and tend to flatten as the well density is decreased. The results indicate that closer well spacing has resulted in greater recovery.

An example of the careful, detailed field studies conducted for many years by the U. S. Bureau of Mines, is that by H. B. Hill and C. E. Sutton† discussing the "Production and Development Problems in the Powell Oil Field, Navarro County, Texas." In this field, substantial production is obtained from a sand averaging 50 ft. in thickness and 2900 ft. deep. Wells were closely spaced and have been operated without proration restriction. Expulsion of the oil has been primarily by gas expansion aided by edgewater incursion. Per-acre-foot yields on some tracts have ranged from 960 to 1600 bbl. After carefully analyzing the performance of four contiguous tracts where substantially similar conditions are said to exist, but where different spacing intervals were

†U. S. B. of Mines Bull. 284, 123 p., 1928.



ALWAYS SMOOTH SLEDDING WITH

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ROLLER BEARINGS

TABLE 2

Ultimate productions for wells of different spacing producing from various zones in the Santa Fe Springs Field, California

(After A. S. Hayes[13])

Zone	Spacing, acres per well	Ultimate production per well, bbl.	Ratio of ultimate per well productions	Ultimate production per acre, bbl.	Ratio of ultimate per acre productions
Meyer	4.35	424,000	100	97,500	100
	0.66	322,500	76	492,200	505
Buckley	4.44	352,090	100	79,300	100
	1.19	145,500	76	121,900	154
O'Connell	5.71	833,660	100	146,000	100
	0.89	295,025	35	331,900	227
Clark	5.0	305,000	100	61,000	100
	0.85	136,260	45	159,800	262

allowed, the writers conclude that "close drilling, approximately 2.25 to 2.5 acres per well, together with rapid development, will show the largest recovery in barrels per acre and in percentage of original oil content removed; likewise, it will give the quickest return of investment and profit. . . . However, the return per dollar of investment will not be as large as that from more conservatively drilled areas."

In a recent U. S. Bureau of Mines publication, presenting an analysis of production data from the Mexia-Powell fault-line fields of Texas (Repts. of Inv. No. 3712), Hill and Guthrie assemble results from which the data of Table 4 are extracted. The figures given are averages for groups comprising many individual properties, all of which produce from the Woodbine sands under essentially similar conditions. The writers reach the conclusion that closely spaced wells procure larger per-acre-foot yield than widely spaced wells, but point out that it is impossible to prove from the available data that for each field as a whole fewer wells would not have produced as much oil, and at lower cost.

Some authorities, although admitting that wells may exert a drainage influence over wide areas, especially under conditions of restricted flow, nevertheless believe that close spacing will result in greater ultimate recovery than wide spacing because of irregularities in stratigraphy and lithology in reservoir rocks that restrict free movement of oil. Nature's methods of sedimentation seldom result in strata of uniform thickness, continuity, and permeability. Close inspection of reservoir rocks will usually disclose minor shale "partings," cross-bedding, "stringers" of secondary minerals deposited in small crevices cutting across bedding planes, minor faults, and other stratigraphic discontinuities that impede free drainage of reservoir fluids. It is reported,‡ for example, that careful inspection of 4000 ft. of continuous cores cut horizontally through the First Venango sand in an oil mining enterprise near Franklin, Pennsylvania, showed more than a thousand such partings. Surely, under such conditions, we should expect more complete recovery from closely spaced wells.

‡"Horizontal Drilling From Bottom of Shaft in Pennsylvania Field," by H. L. Schultheis, *Oil & Gas Journal*, October 14, 1943, p. 49-51, 64.

Wide Spacing

The foregoing field evidence would appear to confirm the opinion held by many operators that closer spacing of wells results in increased per-acre yields, at least in fields where gas energy is supplying the expulsive force and wells are not unduly restricted. In each case, it is also evident that wider spacing increases per well recovery and per barrel cost. With this latter statement there can be no disagreement, but many authorities who have contributed much to our knowledge of drainage principles during recent years do not agree that closer well spacing will result in greater per acre yields, particularly where the rate of production is restricted by proration. They contend that closer spacing merely hastens recovery, and that excessive drilling may result in wastage of gas energy, which actually reduces rather than increases ultimate recovery. Following are some of the field data and opinions based on field performance that have been marshalled in support of this point of view.

Based on the results obtained by exploitation of various fields in Texas—mostly water drive fields—Suman[36] concludes that because of more efficient use of reservoir energy, wide spacing (20 to 40 acres per well) is procuring greater ultimate recovery than would be possible with closer spacing. The Yates field, for example, is regarded as a model of efficiency, yet much of the field is drilled with but one well to 100 acres, and the average is one well to 40 acres. In 1934, the Yates field had been under development for 8 years and had produced 30 percent of its estimated recoverable oil; yet 95 percent of its production was being obtained by natural flow and the formation pressure had declined only 22 percent. Initial productions of wells had scarcely diminished below those of earlier years. Suman also gives figures showing the very great financial advantage of wide spacing. Estimates of average production cost in the more widely spaced fields are only about one-fourth that for such fields as Powell and Luling, where the spacing has been 3 to 4 acres per well.

Wood[47] offers estimates of relative recoveries for different well spacings in water drive and gas drive fields. He concludes that just as much oil is produced in a water drive field with one well to 40 acres as with one well to 10 acres. In a gas drive field, he estimates that if we may expect 40 percent recovery, which is believed to be a maximum, with one well to 10 acres, we can obtain 70 percent as much, or a recovery of 28 percent, with one well to 40 acres.

Foley[8] points out that many of the earlier studies that led to the conclusion that close spacing is advantageous in increasing ultimate recovery, were made in fields that were operated without restriction. He suggests that reservoir pressure gradients are different in a restricted field, and that the conclusions based on earlier practice may not apply in heavily prorated fields. The fact that secondary recovery methods are successful in obtaining substantial recoveries is proof that primary recoveries are contingent upon efficiency of utilization of reservoir energy, and this may conceivably influence and be influenced to an important degree by well spacing. Knowlton suggests that efficient use of reservoir energy will permit of wider spacing of wells. Under given reservoir conditions each well has its most efficient rate of production. Likewise, each reservoir has its maximum efficient rate of production. Dividing the maximum reservoir rate by the optimum rate for the average well, determines the number of wells that should be drilled. With these principles all can agree, but determination of these most efficient rates is a difficult problem, dependent upon criteria that are often indeterminate.

Wyckoff[Δ] states that many years of intensive research has failed to disclose any physical phenomenon that would limit the drainage influence of wells, and that this applies irrespective of the character of the expulsive force. Such a conclusion would justify a wide spacing program, limited only by economic considerations. Muskat concurs in this conclusion and states that for highly permeable sands, little additional ulti-

*Δ"Factors Affecting Reservoir Performance," A.P.I. Drilling and Production Practice, 1940, pp. 105-114.

Photo by U. S. Army Ordnance Dept.

Gun Production Speeded by Dual Boring

The speed of casting gun barrels by the Army Ordnance Department's centrifugal method sets the tempo for subsequent machining operations.

By this method, molten steel is poured into a cylindrical mold while it spins at high speed in the rotary machine. Centrifugal force holds the metal against the mold, leaving slag concentrated around a small central hole. In the boring operation, this slag is removed in a minimum of time by the huge machine pictured above. Boring the barrel from both ends simultaneously, this machine is capable of turning out a 90-millimeter gun barrel in approximately 2½ hours.

The Dickson Gun Plant, manned and operated by Hughes Tool Company, is the only arsenal producing gun barrels by this method outside the Ordnance Department's plant at Watertown, Mass. . . . this production by Hughes is in addition to *tools for the essential Oil Well Drilling Industry.*

HUGHES TOOL COMPANY
HOUSTON, TEXAS
Senior Organization for . . .
HUGHES AIRCRAFT STRUT DIVISION • DICKSON GUN PLANT • HUGHES AIRCRAFT CO.

TABLE 3

Cumulative productions for wells of different spacing in the Long Beach Field, California

(After Roberts and Sweeney[32])

Spacing, acres per well	Recovery per well to July 1, 1929	Ratio of per well productions	Recovery per acre to July 1, 1929	Ratio of per acre productions
2.92	266,569	100	91,395	100
0.71	140,399	53	196,558	215
3.23	231,638	100	69,990	100
0.83	227,961	98	273,553	398
3.33	470,685	100	141,206	100
0.87	157,468	33	181,088	128
2.5	206,926	100	82,770	100
1.0	138,050	67	138,050	143
3.0	147,404	100	49,135	100
0.88	137,387	94	155,705	317

mate recovery is gained by close spacing. He concedes, however, that for very "tight" sands, spacing should be closer to obtain appreciable recoveries before individual well productions drop below the economic limit of profitable operation.

Cheney[3] offers the evidence of 2 wells in support of his contention that wells may be widely spaced without loss of ultimate recovery, even in fields where water drive is not the dominating expulsive force. In one case, a well in the Sinclair-Moren pool, Young County, Texas, was completed with an initial production of 1100 bbl. of oil and 12,000,000 cu. ft. of gas per day, and produced without competition from other wells for a period of 8 years. During this period, the well produced 1,160,000 bbl. of oil and, after 8 years, was still flowing about 90 bbl. per day against a back pressure at the wellhead of 120 lb. per sq. in. After 10½ years, the accumulated production of this well, plus predictable future production, was estimated at 1,500,000 bbl. The oil bearing portion of the reservoir rock in the vicinity does not exceed 40 ft. It is believed that production under gas drive for an oil sand of this character could not exceed 350 bbl. per acre-foot, or 14,000 bbl. per acre. On this basis, it is asserted that the well effectively drained an area of at least 100 acres.

After 8 years of non-competitive production, 7 other wells were drilled within the area of influence of this well. The largest of them developed an initial production of 698 bbl. per day, but all quickly declined to about the same rate. During 6 years of competitive production, these 7 wells produced 300,000 bbl., when the field pressure was substantially depleted, though the wells were still producing about 10 bbl. per well per day. The original well reduced the gas pressure of the pool about 50 percent in producing 1,160,000 bbl. of oil. Seven later wells resulted in loss of most of the remaining field pressure in producing only 300,000 bbl.

In the other instance cited by Cheney,[3] a well in Stephens County, Texas, was completed in June, 1924. The rate of production was too small to encourage competitive drilling. During 10 years of continuous production, the well produced 325,000 bbl. from a formation that commonly averages less than 3000 bbl. per acre. Ten years after completion, the rate of production of the well has diminished only 25 percent from its initial peak.

The producing formation in portions of the East Texas field is said to be highly permeable. The field is producing under water drive and the rate of production has been regulated to keep the formation pressure above the bubble-point of the oil. In some areas in this field, wells attaining high rates of production for only short periods of time have been found to cause noticeable pressure drop in wells from 2000 to 3000 ft. distant.

Based on representative physical data, an allowable production of 20 bbl. per well per day, a minimum production rate of 3 bbl. per well per day, an investment of $22,500 per well, an operating cost of $1800 per well per year, selling price of oil 98 cents per bbl., an interest rate of 6 percent and a one-eighth royalty, Jones[18] estimates the optimum spacing for wells in the dolomite reservoir rocks of the Texas Panhandle to be 18 acres per well, or one well per 136,000 bbl. of recoverable oil. Although some authorities disagree with the procedure followed in this study, they do not disagree with the principal conclusions reached.

Zorichak[50] reports the results of a study of well spacing in various Rocky Mountain fields by a committee of the American Petroleum Institute, strongly supporting wide spacing of wells. In the Greasewood field, Colorado, wells spaced apart at the centers of 40-acre tracts were found to influence each other. Operators were considering 80-acre spacing. In the Jal field, New Mexico, operators believe that a single well will ultimately produce more oil than a group of wells drilled within drainage radius of each other. In the Hogback field, New Mexico, 7 wells produce from 160 acres, or 23 acres per well. Production over a period of 8 years was nearly constant. A similar situation exists in the Iles field, Colorado, where there is one well for each 60 acres. In the Salt Creek field, Wyoming, in 1932, there were 315 wells producing from the First Wall Creek sand, or an average of one well for each 13.8 acres. In the same field, the Sundance sand is considered to be fully developed with 23 wells, or one for each 29 acres. It is believed that the last 13 wells did not increase the ultimate recovery, merely taking oil that might have been produced by earlier wells. In the Pondera field, Montana, the last 27 wells drilled did not materially increase the ultimate recovery. Instead of drilling one well to 10 acres a wider spacing would have drained the field as effectively. The Cat Creek field was drilled with an allowance of 4.5 acres per well, but it is believed that 70 unnecessary wells were drilled and that the field could have been fully drained with one well to 10 acres. It is believed that the Rock River field of Wyoming has 19 unnecessary wells and that with a spacing of one well for each 20 acres, the field is overdeveloped. Zorichak believes that when a field reaches that state of development when additional wells do not increase the rate of production nor arrest the decline, each additional well drilled merely takes production from wells already producing.

Rhys-Pryce[31] reviews a situation in the La Rosa field, Venezuela, where overdevelopment has apparently resulted in loss of ultimate recovery. A well produced for nearly two years before four offset wells were drilled, spaced 657 ft. apart. The production of the original well immediately dropped about 30 percent and its rate of decline increased. Studies of the cumulative production curves for the five wells showed that the flowing recovery of the initial well, if allowed to produce without competition, would have exceeded its actual flowing recovery plus that of the four offsets. Another case cited by Rhys-Pryce is that of a well in the Dominguez field, California. Here three wells, spaced 660 ft. apart, were collectively producing 1000 bbl. per day. A fourth well was drilled and all four wells still produced only 1000 bbl. per day.

J. O. Lewis[21] emphasizes the fact that bypassing of oil by formational gas in the reservoir rock is an important factor in determining the efficiency of oil recovery, perhaps at times a more important consideration than the spac-

Baash-Ross News

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PETROLEUM ENGINEER EDITION

MORE and more operators today are standardizing on *unitized* equipment for the majority of their drilling and production operations. Why? Because equipment of this type has proven *far superior* for modern field conditions. It is easier to handle, and therefore far *safer* to use. It is better designed, better engineered, and so is able to give *longer* and *more economical* service life as well as outstanding time and labor saving advantages under *all* conditions!

WHY

A completely unitized tool

engineered for the rigid requirements of all modern drilling operations, is the Baash-Ross Type "DU" Rotary Slip. It incorporates features proven successful through years of oil field use. It is made in both the "Regular" Type—with liners 12" long for wells to 8000 feet in depth—and the "Long" Type with liners 16" long for the deepest wells you drill. Point by point, here are the reasons why the "DU" Slip has *all* the features you want for your drilling operations. . . .

▶ 3-POINT CONTACT IN MASTER BUSHING

Only in a *unitized* slip do you get the important feature of continuous, even setting of all slip sections around the circumference of the pipe. The Type "DU" has 3 body sections flexibly hinged together so that they set at the *same level* in the master bushing at all times. This eliminates danger of crimping the pipe, and insures a full 3-point contact in the master bushing for equal weight distribution of the drill pipe load. The flexible hinges between body sections also prevent binding, speeding up handling on every pipe connection!

▶ FULL LENGTH LINER RETAINERS

Two liners deeply recessed in *each* body section seat upon a shoulder, and are held against lateral movement by the dovetail edges of the body casting. The liners are retained firmly in the body by a long double keystone key which fits in a mating groove between them. This method of securing the liners is an important feature. It insures that all strains involved in supporting the pipe and in breaking out joints are transmitted *directly to the slip body. All retaining bolts, pins, or other means of securing the liners, which might shear and allow the liners to fall in the hole, are completely eliminated in this assembly!* Yet . . . both liners in each body section can be quickly removed by pulling one cotter key and sliding out one retaining key!

▶ LIGHT IN WEIGHT—BALANCED

Type "DU" Slips have ample strength to support the longest pipe strings, yet are exceptionally light in weight. The heat treated alloy steel bodies are cored to eliminate excess metal, and the tapered areas are relieved at the proper points to eliminate any tendency to stick in the master bushing bore, insuring fast, easy handling at all times. Uniform weight of each body section gives balance for ease of operation and the flattened toes enable the tool to stand solidly on the rotary or derrick floor. Large handles with loops safeguard workmen's hands and are practically indestructible. They are so designed that they rest on the rotary when released, out of the way of the descending elevators.

▶ FULL LENGTH LINER GRIP

An outstanding feature of the Baash-Ross "DU" Slip is the gripping surface provided by the liners. The small truncated pyramids are proportioned to insure a positive, non-slip grip on the pipe, yet hold penetration into the body of the pipe at a minimum. Distribution of load is evenly divided between all liners, and due to the flexibiltiy of the entire assembly a *full-length* grip is insured. Stress concentration at any one point is prevented by means of the horizontal and vertical relieved areas in the liners—a vitally important feature!

▶ INTERCHANGEABLE LINERS

To keep your slip investment at a minimum, Baash-Ross designed the Type "DU" so that each body size can be readily converted for use with a wide range of drill pipe sizes by merely installing liners of the proper size. For example, a 4½" body size will handle all sizes of drill pipe from 2⅜" O.D. to 4½" O.D. by using interchangeable liners of the specific size. Interchangeable liners are inexpensive, and can be installed right on the rig without special tools or instructions.

Why not get the positive protection, the easier operation, the greater all-around savings provided in the Baash-Ross Type "DU" Rotary Slip? For further details on this outstanding tool, contact your Baash-Ross representative, or write direct!

TABLE 4

Ultimate productions for wells of different spacing in the Mexia-Powell Fault-Line Fields of Texas

(After Hill and Guthrie in U. S. Bureau of Mines R.I. 3712)

Field	Acres per well	Indicated ultimate oil production per acre-foot
Wortham	3.0	670
Wortham	2.2	1,095
Wortham	1.9	1,528
Wortham	1.8	1,735
Mexia	10.7	268
Mexia	7.45	585
Mexia	4.5	282
Mexia	4.3	880
Mexia	3.31	1,051
Powell	4.4	795
Powell	3.7	1,117
Powell	2.9	1,232
Richland	2.66	1,214
Richland	2.15	1,517
Currie	5.80	770

ing interval between wells. As the reservoir rock is depleted of its oil content, because of gas bypassing, the gas becomes less and less effective as an agent for forcing the oil from the sand, and consequently a larger and larger proportion of gas energy is wasted in moving each additional barrel of oil. Thus, to recover the second 10 percent of the oil content of the reservoir requires a greater amount of gas energy than that necessary to produce the first 10 percent, and to recover the third 10 percent consumes many times as much additional energy. Wide spacing of wells probably results in less bypassing of oil by gas, and more efficient utilization of gas energy than when wells are closely spaced. Lewis concedes that close spacing of wells tends toward additional ultimate recovery, but believes that it is better to err on the side of wide spacing, as more wells can always be drilled later if circumstances warrant. Modern scientific principles of oilfield exploitation are making possible a trend toward wider spacing.

Authorities agree that the results of field experiments conducted in the Bradford field, Pennsylvania, to determine the water injection pressure necessary to cause movement of fluids in water flooding operations, are significant in analysis of the well spacing problem. Nowels and Maxwell[26] report that to deliver 20 bbl. of fluid per day to the average recovery well in this field, about 5 lb. of injection pressure is necessary to overcome sand resistance per linear foot of travel of the fluids through the reservoir rock.

The method of exploitation to be employed in drainage of a field should doubtless be given consideration in determining the spacing of wells. Where it is planned to reinject gas produced with the oil and operate the field by the pressure maintenance method, wells may be more widely spaced than when it is planned to utilize only the energy afforded by nature. Similarly, if it is planned to apply an artificial gas or water drive during the latter part of the economic life of the field, wells may be widely spaced with the expectation that whatever oil nature's energy may fail to produce in the period of primary recovery will be procured by artificially developed energy during the later period of secondary recovery. On the other hand, if the secondary recovery method to be employed requires close spacing of wells, all wells might as well be drilled at the outset of operations if any advantage would be gained by their use during the period of primary recovery.

MacRoberts[22] offers a series of mathematical formulae for computing the rate of production of gas wells with varying spacing, and applies them to a particular set of assumed conditions. From this analysis, he concludes that intensive drilling in gas reservoirs will increase ultimate recovery but slightly. One well on each of the 11,000 acres in the assumed field will, he estimates, result in the production of only 1.08 percent more gas than is possible to produce through a single well. The residual gas in the reservoir will be between 4.6 and 6.0 percent of the original gas content, no matter how intensively the field is drilled.

Conclusion

Well might we despair of drawing valid conclusions of general application from such a mass of conflicting evidence and opinion as is presented in the literature of this subject, yet the following tentative conclusions seem now to be reasonably well established:

1. Wide spacing of wells results in greater per well yields, lower per barrel production costs, and greater profit on capital invested in development.

2. In competitive fields, tracts with closely spaced, unrestricted wells develop higher per acre yields than tracts with widely spaced wells.

3. Water drive fields that are endowed with an inexhaustible source of expulsive energy permit of wider spacing of wells than do gas drive fields where the expulsive energy is definitely limited.

4. Wells may exert drainage influence over wide areas in continuous, permeable strata, but local stratigraphic and lithographic irregularities will restrict free and continued response of the rock fluids to the drainage influence in many reservoirs. Where this condition exists, close spacing of wells will procure greater per acre yields than wide spacing.

5. In unitized fields, or where close cooperation between operators is possible, wells may be more widely spaced. Greater efficiency in control of reservoir energy, possible under such conditions, permits of recoveries as great or perhaps greater than those possible with closer spacing under competitive conditions.

6. The question of whether in a unitized gas drive field as much oil can be produced with few wells as with many, assuming maximum possible efficiency in control of reservoir energy in each case, is still a question upon which there is no general agreement.

7. In unitized water drive fields the spacing of wells becomes largely a matter of the rate of production desired, and economic considerations are of primary interest.

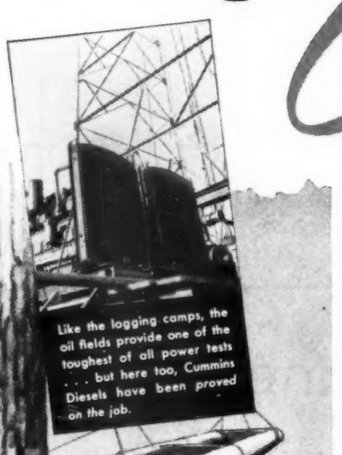
8. The oil producer, whose interest lies in obtaining maximum profit from his operations rather than maximum production of oil, finds the well spacing problem one to be solved largely by economic rather than physical considerations.

9. Spacing programs should be planned to serve the needs of both primary and secondary exploitation, or throughout the economic productive life of the tracts on which the wells are located.

10. No dependable all-inclusive formula that can be applied broadly to solution of the well spacing problem has yet been developed, nor is it considered likely that such formula will be developed, because of the complexity of the physical and economic relationships involved and the intangible character of some of them.

☆ ☆ ☆

"cheap logs" is Conservation



Like the logging camps, the oil fields provide one of the toughest of all power tests . . . but here too, Cummins Diesels have been proved on the job.

In 1936, with the introduction of the Cummins Diesel, the logging industry started on a new era of lower operating costs and added savings in manpower. "Shows" which would have been inaccessible or highly unprofitable became duck soup when Cummins Diesel-powered trucks demonstrated their ability to handle loads of 100 to 200 thousand pounds at an over-all operating cost far below previous transportation figures. The Cummins Diesel-powered yarder was easy to move and the engine's flexibility and torque characteristics, plus its proved economy and direct savings in manpower, soon made it the choice of shrewd loggers.

Today, after seven years' experience with all types of diesels, the Cummins Diesel is the first choice of the loggers in trucks, yarders, loaders and donkeys because it has made "Cheap Logs" a fact. Cummins Diesel power put the logger in a position to deliver more logs at a lower cost . . . this is *real* conservation. CUMMINS ENGINE COMPANY, Columbus, Indiana.

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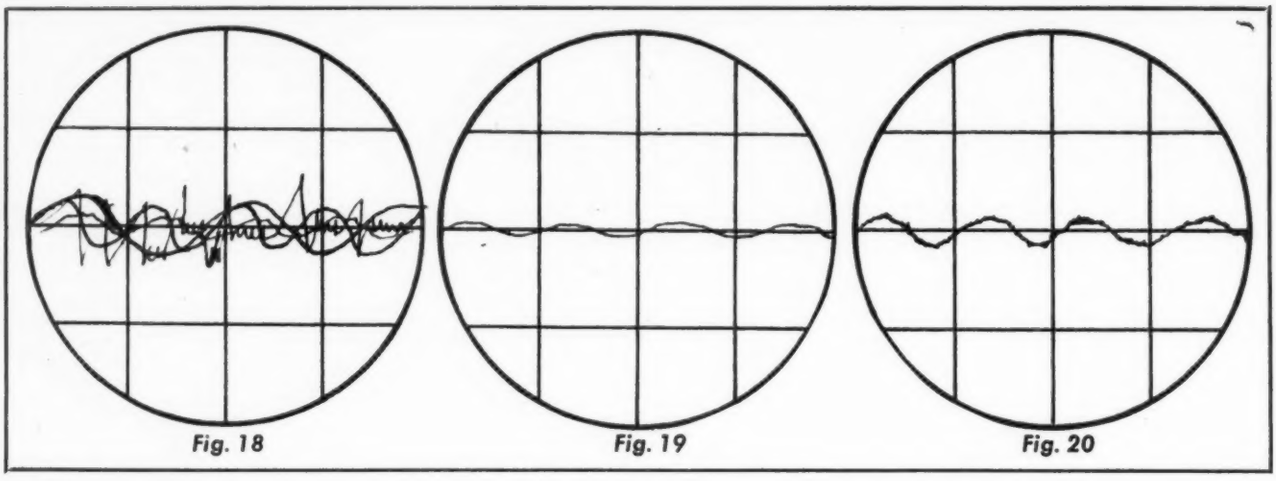


Fig. 18 Fig. 19 Fig. 20

Interference on Telephone Lines Caused by Cathodic Units

PETROLEUM Exclusive

PART 2 (Concluded)

by Paul F. Marx

Technical Engineer, U. S. Maritime Commission

THE installation of the filter discussed in Part 1 on one of the cathodic unit generators cleared the noise and the oscillograms were as shown in Fig. 18 and Fig. 19, the former before the filter was installed and the latter after it was installed.

Fig 21

When the vertical sweep of the oscillograph was magnified to its limit, a "fuzziness" could be seen and Fig. 19 then looked like Fig. 20. This remaining interference was not perceptible, however.

Telephone interference may also arise from various types of cathodic protection units. If no oscillograph is available, the trouble may be eliminated by the "trial and error method." Test coils, together with a test capacitor box, can be used.

The coils should be made in a manner previously described, except the coil should be wound with about 250 turns, and a test tap brought out at convenient locations every 25 turns. These taps should be numbered. (Fig. 21.)

The number of turns can then be varied easily and the choke coil used as a laminated core coil or an air core coil.

A test capacitor box can be made by paralleling a number of capacitors and bringing three pair of leads from the box, the individual capacitors being equipped with 1 amp. toggle switches, so they can be manipulated with ease. The switches should be suitably numbered. (Fig. 22.)

The wiring diagram of the test capacitor box is shown in Fig. 23.

The test coils and test capacitor box should be installed at the cathodic unit to be tested. (Fig. 24.)

Two portable telephone test sets should be used, one situated about 50 ft. from the cathodic unit, just close enough so the noise of the engine does not interfere with the testers hearing in the telephone receiver. The other

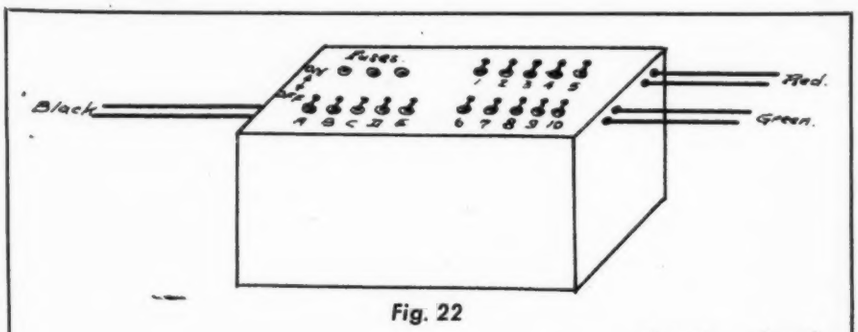
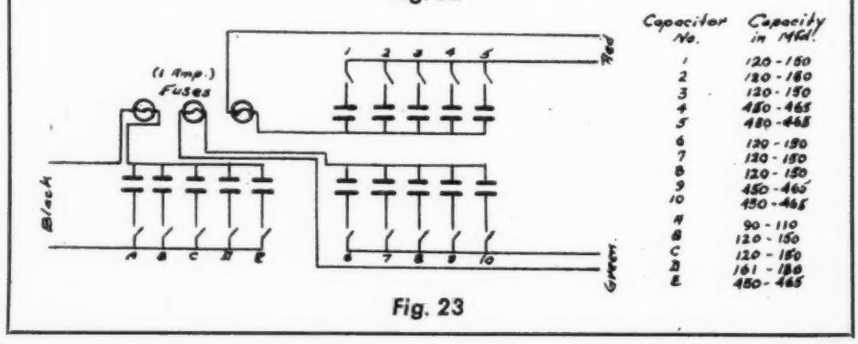


Fig. 22



Capacitor No.	Capacity in Mfd.
1	120 - 150
2	120 - 150
3	120 - 150
4	450 - 465
5	450 - 465
6	120 - 150
7	120 - 150
8	120 - 150
9	450 - 465
10	450 - 465
A	90 - 110
B	120 - 150
C	120 - 150
D	161 - 180
E	450 - 465

Fig. 23

LADISH

forged steel flanges

Connecting the vital arteries of Industry, Ladish flanges are produced under the highest metallurgical and engineering standards.

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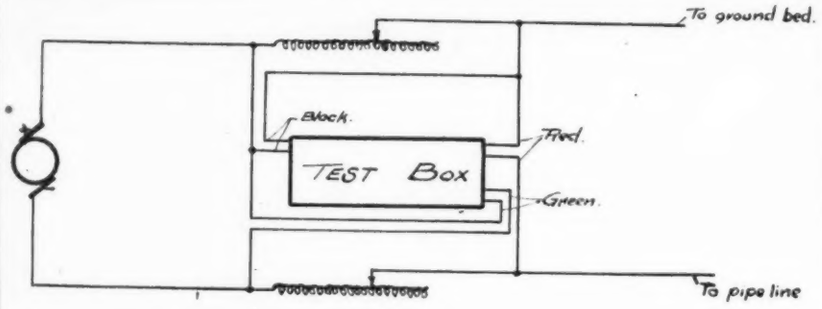
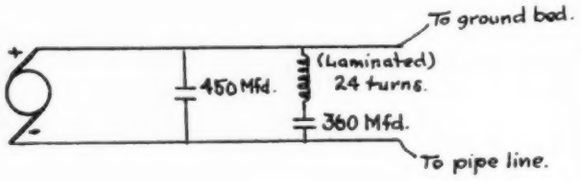


Fig. 24



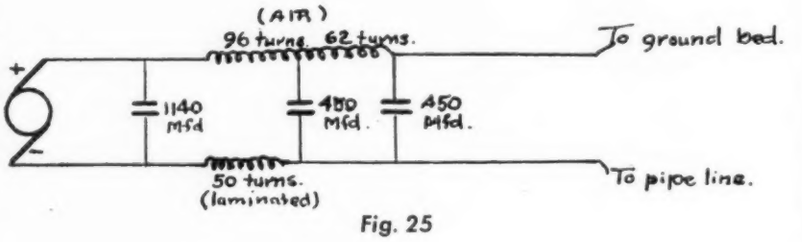


Fig. 25

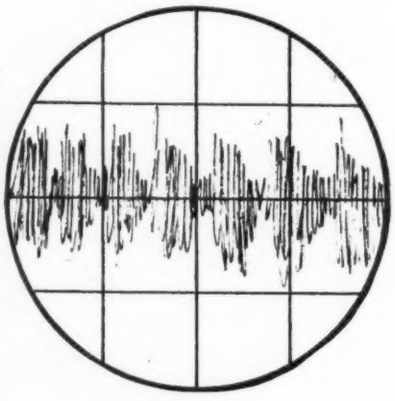


Fig. 26

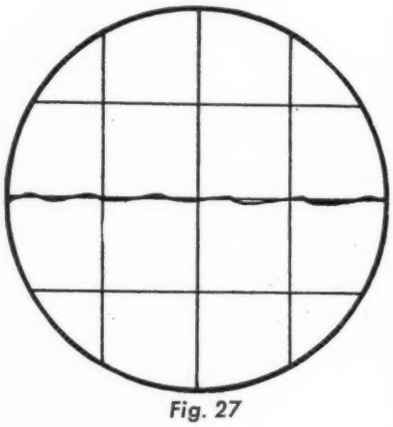


Fig. 27

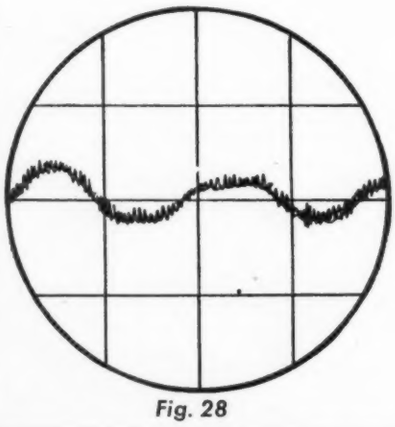


Fig. 28

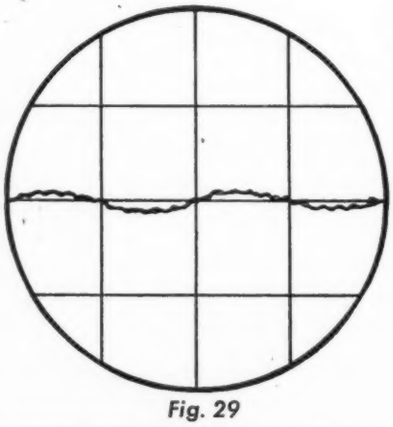


Fig. 29

should be from 500 to 1000 ft. from the unit.

A single wire, grounded circuit should be used. Black iron stove-pipe wire will suffice.

Often a short piece of wire connected to a strand of barbed wire, on a barbed-wire fence, will make a good circuit. The fence wire must not be grounded and should be cut at the far end, where the second test set is connected, to prevent grounds farther up the line.

This temporary wire can also be cross connected to the telephone circuit giving the trouble and the second test set used by the switchboard in the telephone office.

When tests are to be made, the person at test set No. 2 (remote from the unit) contacts the tester at test set No. 1, giving instructions to cut in or cut out certain numbered switches, and also to change the coil connections as desired. The coil taps can be readily connected and disconnected by using large battery clips.

By making various combinations of coil turns and capacities, the effects of increase or decrease in noise interference can be determined and the best combination used.

After the desired combination is attained, a permanent set-up can be installed.

As shown in the wiring diagram of the capacitor test box, fuses are used. It is essential that these be included as they will prevent the loss of capacitors due to current overload. They will also prevent fires from accidental shorts during testing.

The wiring diagrams of the necessary filters required to eliminate the troublesome noise from two other cathodic units are shown in Fig. 25.

As a matter of comparison, the oscillograph was used to note the variations due to different combinations of coils and capacitors. The hook-up used was of the constant K low pass filter type. The vertical sweep on the scanning disk of the oscillograph was measured. The results are tabulated in Table 1.

Electrolytic condensers should never be used for capacitors in field installations as these wet condensers will freeze in the winter.

A generator from a wind driven cathodic unit was taken to an electric shop for tests with the oscillograph. The generator was mounted in a lathe so the speed could be varied. The generator was loaded with an adjustable carbon rheostat. When the generator was running idle, without a load, considerable interference was seen as in Fig. 26.

This noise could be filtered easily

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Petroleum Equipment Company,
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San Francisco, California.

Gentlemen:

You may be interested in a little history of the use of the rolagrip couplings which were explained and sold to us by your Mr. Frank Merkel way back in 1941. We were facing the unwatering of an old mine shaft (vertical), and we planned a two stage pumping job - pump first down to the 525 foot level, and install the 40 H.P. 2 stage centrifugal pump, with which we would unwater, on this level. Then go on down to the bottom level, the 675, with a smaller pump, pumping up into the 525 foot level sump.

This was an economy job. New pumps, but everything else had to spell economy. We found a bunch of used, but good, boiler tubing 3¼" O.D. We planned on welding on 3" butt end threads for the screw joints, and using it for discharge pipe. But, with good fortune we had a rolagrip coupling described to us by Mr. Merkel. We ordered 3 or 4 dozen and started pumping from the surface. We placed a small hand winch directly over the shaft opening, with the cable gripping the pipe near the bottom. We let the pipe down as the water lowered, and kept putting on the rolagrips at the surface with each new length of pipe. Of course, we expected to clamp the pipe to the shaft timbers after two or three lengths had been lowered, but after a while, we found that we could grip the pipe string in the middle, with many lengths hanging loose and held together only by the rolagrips. The lengths above the cable hitch would bow in an arc across the shaft compartment, but as nothing happened, we kept on going. We had as much as 200 feet of pipe hanging below the cable hitch, through which water was being pumped - and it throbbed and jerked, but the rolagrips held tight. After we got down, the same pipe line, with which we unwatered, was stapled to the shaft timbers, and is still being used, with many of the original rolagrips holding it together. When the acid water would eat through a thin or weak place in the pipe, it was always such an easy job to make a change without looking up and down the shaft for the "conventional" union. The boys measured the length of the pipe, got another just that length, brought it down, unfastened the rolagrips and slipped it in.

I am sending you one of the rolagrip couplings which was subjected to a rather unusual experience. The acid water in the shaft runs down the sides of the shaft and down the pipe and every place. It eats iron. It does it most effectively when the water is broken up into splashes and combines with oxygen. The water running down the pipe on the rolagrip I am sending you, did its deadly work on the bolts where it riffled and splashed, and you will see that this portion is practically eaten away. The rolagrip did not give up its seal tight grip on the pipe joint until the bolt at one end had been entirely eaten away. Then it eased it, and a leak was discovered. As you see, the whole coupling is much eaten. But, inside, the grips and the rubber gasket were still doing their work. The gasket was put into another coupling.

Yours very truly,
Keystone Copper Co.

H. E. Bush
Superintendent.

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with capacitors. The resulting curve is shown in Fig. 27.

When the generator was pulling a high load there was less noise. (Fig. 28.) This noise was difficult to filter and required a filter consisting of capacitors and a choke coil. The resulting curve is seen in Fig. 29.

This type of generator, with a 2 kw. output, is slow speed and lower frequency curves resulted than on the natural gas driven type.

Radio interference is also produced by cathodic units. Several farmers reported considerable interference on their radios from wind driven cathodic units that were in close proximity to their farm houses. They noticed that when the units were operating, their trouble occurred and when the wind did not blow and the unit was idle, no interference was encountered. After this condition was experienced, several the various steps involved in finding a others complained about the same trouble; however, this could be traced to faulty neon signs and overloaded power transformers.

This article was written to illustrate the various steps involved in finding a solution to the problem of noise interference on telephone lines created by cathodic units and with the hope that it may prove beneficial to those confronted with a similar problem.

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TABLE I

Coil core	Wire size	No. of turns	Capacitors, mfd.	Oscillograph vertical sweep, in.	Remarks
Laminated	0.120 x 0.560	48	....	1.0	No filter
Laminated	0.120 x 0.560	72	....	0.8	
Laminated	0.120 x 0.560	96	....	0.7	
Laminated	0.120 x 0.560	120	....	0.6	
Laminated	0.120 x 0.560	158	....	0.5	
Solid		216	....	0.4	
Laminated	0.175 x 0.340	158	150	0.8	Soft iron core
				0.2	Capacitor on generator side. Laminations in or out.
Laminated	0.175 x 0.340	158	300	*	Capacitor on generator side.
Laminated	0.175 x 0.340	48	450	*	
Laminated	0.175 x 0.340	24	600	*	
Laminated	0.175 x 0.340	24	600	*	
Laminated	0.175 x 0.340	24	600	*	300 mfd. on each side of coil.

*Vertical sweep less than 0.1 in., noise interference eliminated.

P 501.61

Subsurface Disposal of Brines in Kansas

PRESERVATION of thousand of acres of farm land, grazing land, and potable water areas in Western Kansas is being made possible by efficient subsurface disposition of otherwise harmful oil field brines, Dr. R. R. Sayers, director of the Bureau of Mines, reports.

Dr. Sayers said a joint survey by the Bureau and the Kansas State Board of Health discloses that the injection of oil field brine into subsurface formations containing mineralized waters now is considered the most satisfactory and effective means of disposal. A publication describing the research has been issued by the Bureau of Mines.

Although other disposal methods, such as impounding brines in evaporation ponds and controlled diversion into surface streams, have been investigated, the survey indicates that these methods are not entirely satisfactory in Kansas, principally because the volumes of brine to be disposed of are large, the soil extremely porous, the net evaporation low, and the rainfall insufficient for adequate dilution of the brine.

Disposition of oil field brines long has been an acute problem among petroleum producers in parts of the United States, particularly in agricultural areas because of the harmful effects of mineralized water on fresh water supplies, vegetation, and aquatic and other animal life.

Recognizing that many surface and subsurface fresh water sources were being damaged or seriously endangered with resultant heavy financial burdens on oil operators, farmers, stock raisers, and municipalities, the Kansas State Legislature, in 1935, approved an act that permitted the return of oil field brine to subsurface formations that contain mineralized waters.

Brines associated with petroleum deposits often contain more dissolved salts than sea water and one of the greatest difficulties attending disposal by subsurface injection is the treatment of the brine to minimize the transmission of suspended solids into the disposal well. Produced brine usually is unstable chemically and tends to precipitate solids. Much of this solid material may be carried in suspension and therefore will clog the face of the disposal formation in a relatively short time, particularly if the formation has low permeability, said Peter Grandone and Ludwig Schmidt, petroleum engineers who represented the Bureau of Mines in the survey.

The joint survey by the Bureau of Mines and Kansas State Board of Health covers oil fields in 16 Kansas counties and includes the collection of statistical data on volumes of brine handled to January 1, 1942, number of disposal wells, number of wells served, oil-producing and brine-disposal formations, brine-gathering systems, methods of handling brines, injection pressures, methods of completing and equipping disposal wells, and life of disposal wells.

The research shows that there were 155 active and 47 abandoned disposal wells as of January 1, 1942. These wells had handled a total of 255,346,000 bbl. of brine, which came from 10 oil producing formations and was injected into 14 disposal formations or zones.

All 202 disposal systems were of the semiclosed type and 45 employed filtration, predominantly sand filters, and only 2 used chemical treatment. Most systems provided open storage for the brine, usually consisting of concrete pits equipped with baffles.

The joint investigation in the Kansas field indicates that operators virtually have abandoned chemical treatment for the stabilization of brines, but in many systems sand filters are used to improve the condition of the salt solutions to be injected. Use of corrosion-resistant pipe has increased appreciably in recent years, and in fields where large quantities of brine are being produced from deep formations operators have established cooperative brine disposal systems to return the brine to the non-oil productive portion of the same formation from which it was produced.

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Drilling Efficiency Under Wartime Conditions[1]

☆ Reasons are given for decrease in number of completions despite accelerated drilling program

by Arch H. Rowan
Rowan Drilling Company

Because of the importance at this time of oil well drilling to the war program, and because of the apparent lack of understanding in some quarters of certain problems confronting the industry, the practical "down-to-earth" facts presented in this paper are particularly pertinent. The writer is president of the American Association of Oil Well Drilling Contractors and vice president of the Rowan Drilling Company.

DRILLING is the foundation of the oil business. Before oil can be produced, transported in pipe lines, refined, marketed, and consumed, holes must be bored into the ground. Whenever there is an imminent shortage of crude petroleum, the tempo of drilling is stepped up. It is this situation we face today, and under wartime conditions that have created many problems not heretofore encountered in the drilling industry. If this shortage should become a protracted reality and should a complete breakdown occur in the drilling industry, we should be confronted with a national catastrophe.

On October 25, there were approximately 1238 rotary rigs running in the United States. Compare this with 759 rigs which were running on January 1, 1943—an increase of 63.1 percent. It was estimated that on October 25 there were 275 idle rigs in the United States, a large percentage of which were incapable of operation due to shortages of certain equipment parts, drill pipe, and drill collars, or because of the unavailability of skilled labor needed to staff these rigs. A total of 32,140 wells was drilled in 1941, the year prior to our entrance into the war; 18,140 wells were drilled in 1942, and 12,972 wells were drilled to October 2, 1943. If the rate of completions for September, 1943, is extended, it is indicated that approximately 17,352 wells will be drilled in 1943. This represents a decrease of 46 percent from 1941 completions and 4 percent from 1942. The decrease in completions this year as compared to 1941 and 1942 has marked significance in view of the accelerated drilling program now in progress and clearly indicates a present lack of efficiency in drilling operations. The slowdown in well completions can be attributed to a combination of factors:

1. A great many of the wells drilling at this time are wildcat wells, which require a greater length of time than wells drilled in proved territory.

2. The depth of drilling today is generally greater than the depth of drilling in 1941 and 1942.

3. The lack of repair parts, the inferior quality of material used in making bits, the shortage of skilled labor, and the use of inexperienced or inefficient labor in the drilling of wells—all these conditions together with governmental restrictions and regulations, are largely responsible for the decrease in well completions, notwithstanding the fact that we are now engaged in an accelerated drilling campaign.

It is this problem that will be analyzed in this paper.

Type of Drilling Rigs

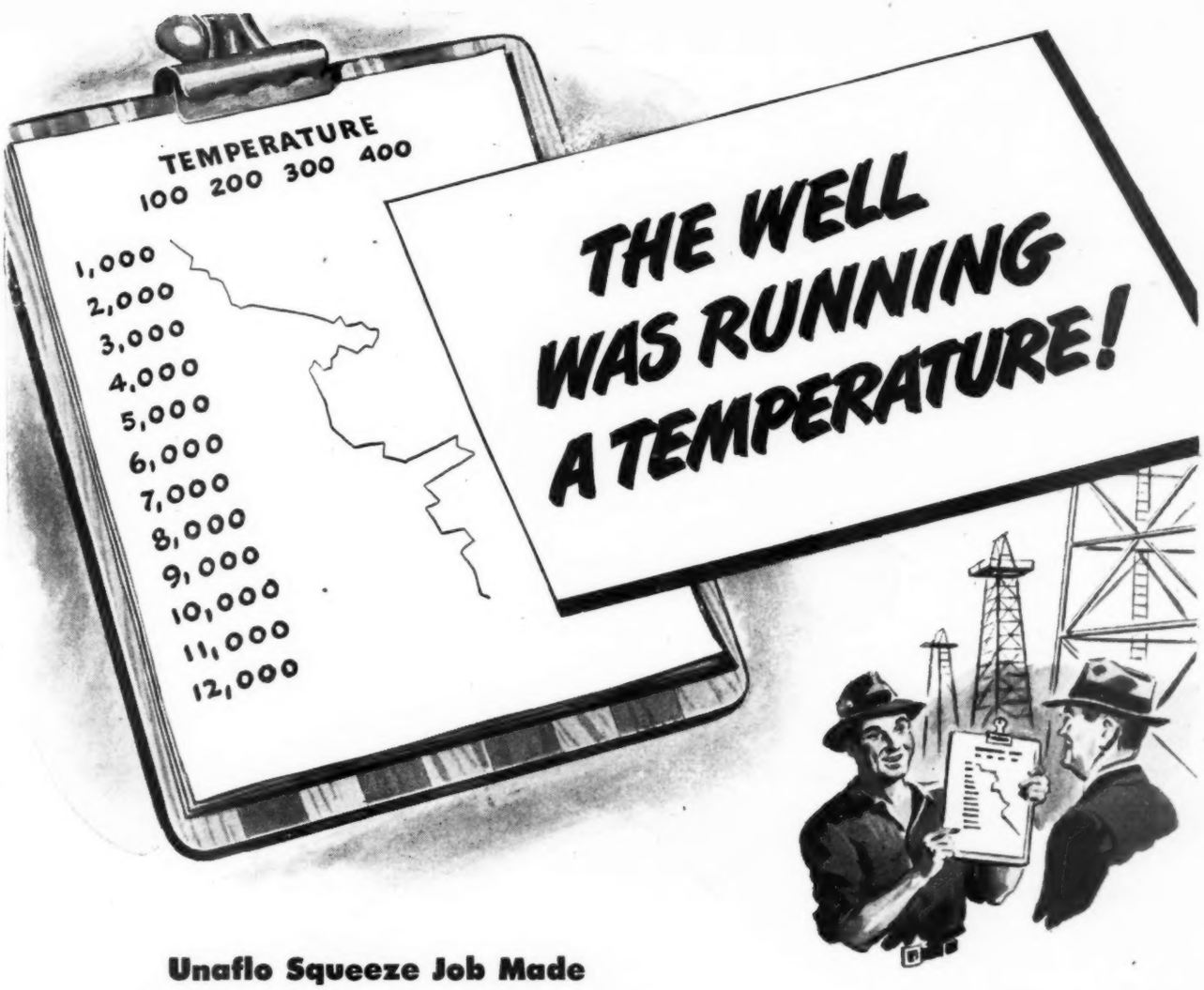
Approximately two-thirds of the drilling rigs operated in the United States today are power driven, the prime movers being butane, gas, gasoline, or diesel engines. These engines are composed of a great number of component parts and require many more replacements than the ordinary steam engines used on drilling rigs powered by steam.

The long established practice in the oil industry has been for the supply companies to stock an adequate supply of replacement parts for these engines and for all types of drilling equipment used on the drilling rig. At the beginning of the war, the authorities charged with the issuance of priorities thought that the contractors or operators of drilling equipment should carry and stock a 90-day supply of replacement parts for the drilling rigs operated by them. It was pointed out that such a plan would be inefficient in that each contractor or operator of a drilling rig would be his own supply house, and that instead of a half dozen supply houses stocking parts, there would be hundreds of supply houses, each attempting to anticipate needs over a 90-day period; and consequently, each contractor would carry in stock excess supplies that would not be needed. This system has now been changed, and we have been told that the supply companies will be permitted to stock replacement parts for drilling rigs; nonetheless, there is still a serious shortage of repair parts for internal-combustion engines. In almost every instance where a part has to be replaced, the supply store does not have the part in stock; it has to be ordered from the factory. This part may be a minor one and cost only a few dollars; nevertheless, the drilling rig is shut down for a period of from two to five days waiting on this part to arrive from the factory. During this period of time, not only the drilling equipment remains idle but also the men who are maintained on the payroll remain idle, doing virtually nothing.

It is apparent that priorities have not been issued high enough to permit the supply companies to maintain adequate field stocks of replacement parts. On a rig that recently completed a well in East Texas, mechanical failures developed, the replacement parts were not available, and shutdown time of 28 days out of 100 days overall time resulted. Parts for rotary table have been on order by my company for 60 days; notwithstanding this fact, this manufacturer is making new rotary tables and offering them to the trade.

There are numerous other instances of long and continuous shutdown of drilling equipment due to the failure to be able to procure promptly repair and replacement parts. The people who manufacture internal-combustion engines for the oil country are also engaged in the manufacture of internal-

[1]Presented at American Petroleum Institute, Annual Meeting, Chicago, Illinois, November 10, 1943.



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combustion engines for the army and navy. The army and navy have given these manufacturers a schedule to meet and have representatives in the various plants to insure deliveries. It is my guess that these representatives of the army and navy are bringing so much pressure to bear on the manufacturers that they will not permit the fulfillment of orders for these necessary replacement parts.

Manpower Problem

After the promulgation of Rule M-68, there was a slump in the drilling of oil and gas wells. Many men who had spent years of training in the drilling industry left this industry and went to work in shipyards, aviation plants, and other war industries where they could be assured 48 hours work per week for the duration of the war. These other industries, working on a cost plus or fixed management fee basis, were in a position to offer attractive rates of pay to these men, and assure them 48 hours steady weekly employment. The operation of drilling rigs requires a high standard of physical fitness, and drilling rigs have generally been manned by young men of this type. In fact, the standards of physical fitness for a drilling crew are approximately the same as those required by the army; consequently, a great many men trained in the drilling of oil and gas wells have been inducted into the armed services.

Drilling oil wells is a hazardous and expensive undertaking. The men who man these rigs must be skilled workers. The War Manpower Commission has established a training period of four years for a driller; yet some officials do not understand the need for such skilled workers. Recently, a high-ranking army officer attached to state selective service headquarters told me that drillers could be trained in 10 days time. This attitude, if maintained by the army, will wreck the drilling industry and bring on catastrophic results.

Generally, replacements of manpower in the drilling industry have come from farm labor or boys reared in rural communities. When a drilling rig was running in a rural community, the farm boys who had been accustomed to receiving meager pay for long hours and hard work have sought employment on drilling rigs where the hours were shorter and the pay much more remunerative. Regulations of the War Manpower Commission today are such that this recruitment of farm labor is no longer possible; therefore, we are faced with the task of using old men and men with physical handicaps who have been refused induction in the army.

One of the chief causes of inefficiency in the operation of drilling rigs today is the enormous turnover in drilling labor. This is caused by the lack of continuity in drilling operations. When a drilling rig becomes idle, the crew is automatically laid off, and this crew is free to seek employment elsewhere, after a period of seven days' layoff. Usually they go to work for other contractors and must learn to fit into a new organization. Contractors generally have followed the practice of working for certain companies; consequently they have become familiar with the method of operation, the manner of completion, and the drilling technique required by that company, and the crews also become accustomed to this procedure; but when a new crew is employed, it means that continuous 24-hour supervision must be given to this crew to see that the work is performed in accordance with the desires of that particular company or operator. With the constant changing of personnel, a burden has been created on the operators of drilling rigs, and in many instances there is a slowdown in drilling operations in view of the fact that the drilling superintendent or toolpusher cannot be on the job 24 hours a day, and the crew frequently is idle for lack of proper supervision. A check was made of the labor turnover in my own company for the first six months in 1943. Out of 591 employees who were on the payroll working on drilling rigs during this six-months period, only 71 were on the payroll on June 30 who were on the payroll on January 1. This is a situation that never has been faced before by the drilling industry.

We are using today rock bits made of inferior steel. The efficiency of a drilling rig is measured by the percentage of the total number of hours the bit is on bottom making hole in relation to the total number of hours consumed in the drilling of a well, including rigging up and tearing down. This means that if the steel that is being supplied us in drilling bits is of an inferior quality, the bit will wear out before it has made its maximum feet of hole and will require that the drillsteam be pulled out of the hole and a new bit put on. The time required to pull the drillstem on a deep hole is, in most instances, considerably longer than the rotating time the bit is on bottom. If an unnecessary and excessive number of trips is made to drill and complete a well, necessarily it follows that additional wear on tool joints, a scarce article, has occurred; additional wear on chain, brake linings, and brake rims has resulted, and additional and unnecessary man hours have been consumed. Under no circumstances should the quality of the bits, drill collars, tool joints, and drill pipe be impaired. It should be kept constantly in mind that the work being done is sometimes two miles away from the derrick floor and out of sight. If fishing jobs develop unnecessarily, as a result of the quality of the material supplied for use underground, an unnnecessary burden is placed on the contractor, valuable man hours are lost, and a correspondingly less number of wells will be drilled with the available rigs.

I have mentioned above the necessity of 24-hour supervision. Virtually all drilling rigs today are staffed by one drilling superintendent or toolpusher to each rig. Many drilling rigs today are on wildcat wells located in isolated areas and long distances from supply stores. Toolpushers are now driving from 2500 to 5000 miles per month. The shortage of tires is a serious problem and prevents these superintendents from giving the drilling rigs the proper supervision. Automobiles cannot be repaired today in a few hours as in the pre-war days. In many instances the local garage does not have the proper part and cannot get the part from the manufacturer, which means that a car driven by a toolpusher may be laid up for several days waiting on a minor repair part. The same thing applies to trucks that are used in the transportation of material and supplies and in moving drilling rigs from one location to another. The time required to move a drilling rig is substantially 50 percent longer today than under normal conditions.

Efficiency Impaired

In summing up, it can be stated with some degree of accuracy that the lack of replacement parts has resulted in a 10 percent decrease in efficiency in drilling operations; the shortage of skilled labor and the use of inexperienced drilling crews has resulted in a 20 percent decrease in drilling efficiency. Although no information is now available relating to the inefficiency caused by the use of inferior bits, it is the consensus among drilling contractors that this inferior

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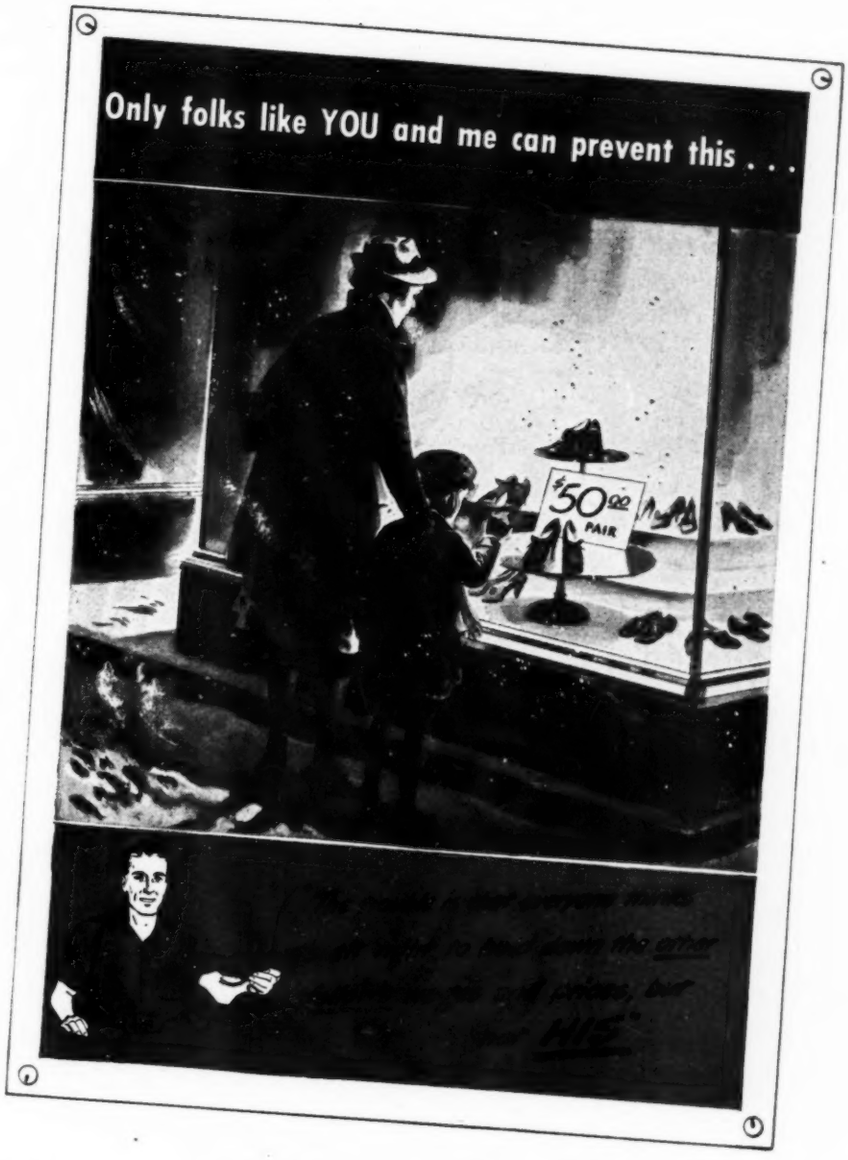
From a paper by C. L. Thomas, N. K. Anderson, H. A. Becker, and J. McAfee, presented before A.P.I., Chicago, Nov. 8-11, 1943.



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quality of steel has resulted in a 10 percent decrease in drilling efficiency.

To remedy these conditions, it is suggested that the companies schedule their operations and attempt to maintain a continuity of operations that would permit the contractor or operator of drilling rigs to maintain his personnel on a continuous employment schedule.

It is suggested that the proper authorities be impressed with the harmful effects of supplying inferior steel for the manufacture of drilling bits. Only 3 percent of the steel used in the drilling bit is actually lost. These bits, when dulled, are gathered up and sent back to the manufacturer and are reprocessed into new bits; consequently, the amount of high grade steel that is consumed in the manufacture of drilling bits is so small and the harmful effect of using inferior quality of steel is so great that there should be no quibbling about the matter.

I should like to mention that a plan has been worked out between the PAW, WMC, and the American Association of Oil Well Drilling Contractors whereby men trained in the drilling industry, who have temporarily gone into other war industries, can now be replaced and brought back into the drilling industry. This plan contemplates a continuity of operations on the part of the drilling contractor, and the WMC has agreed to obtain releases and supply certificates of availability to those men trained in the oil industry, working elsewhere, who desire to return to the drilling industry. It is hoped that this plan will bring several thousand trained men back into the drilling industry.

The selective service officials and the armed services should be told and should now realize that any further raids on the trained personnel of the drilling industry will jeopardize future crude production, which is so vital to our military effort.

No new drilling rigs should be built until an adequate stock of replacement and repair parts is on hand in field stocks of the various supply companies.

If these recommendations are carried out, with the increased number of rigs running now as compared to January 1, 1943, approximately 30 percent more wells can be drilled in 1944 than will be drilled in 1943.

It is sincerely hoped that those in authority will receive these suggestions in the same spirit they are made. The drilling contractors have only two motives; first, to promote the war effort wherever possible, and, second, to do a better job for those members of the oil industry who have made their existence possible.

☆ ☆ ☆

P 094.7

Lubrication Engineers Aid Efficiency of War Plants

LUBRICATION engineers, who once devoted their efforts to selling industrial lubricants, are now engaged in a battle against friction, heat, cold, speed, dust, dirt, moisture and water in the nation's war production factories, the Standard Oil Company of New Jersey revealed recently in outlining some of the unusual ways in which these specialists have speeded up war production through eliminating costly shutdowns, preventing undue wear of manufacturing equipment, and reducing waste and inefficiency.

With war production machines operating at high speeds and under peak loads, lubrication has assumed a new importance, Standard's engineers explained. Much of our war production equipment requires special greases and oils for lubrication. Grease factories are working overtime and the science of lubrication has taken huge strides in recent years as technologists have turned out new lubricants that will minimize wear of war machinery, prevent shutdowns, and promote overall plant efficiency.

These specialists study the nation's war machines in actual production, test them to determine whether they are operating efficiently, check speed and power output, analyze oils and greases used in their operation, determine gear operating temperatures, take plaster impressions of gear teeth to determine the extent of gear teeth wear over given periods and, through expert engineering analysis, trace causes of shutdowns and breakdowns that, if permitted to continue, might well seriously slow America's output of war materials.

One Standard of New Jersey lubrication engineer not long ago found reduced production in a plant making shells for the armed forces. The delay was caused by the breaking of a die in the shell nosing department. The trouble was traced to the use of an incorrect die lubricant. When a new compound was employed the shutdowns ceased and production rose substantially.

In a chemical plant making phosphorous for flame throwers and incendiary bombs production was delayed by faulty lubrication of bearings on the conveyor that carried raw materials to the furnace. The lubrication engineer found that the bearings, subjected to high temperatures, burned out because of an unsatisfactory lubricant. He suggested a high melting point grease. This ended the shutdowns and brought about increased production.

In a cement mill operating around-the-clock for the government, production was delayed because a grease that lubricated bearings on a kiln failed to withstand the high operating temperatures. Frequent shutdowns resulted. A higher melting point grease, of harder consistency than the failing lubricant, was suggested and used. Result: Cooler bearings and increased output.

A Pennsylvania machine shop's contribution to the war was the manufacture of small parts for gliders. Production lagged because in one turning operation the workers could obtain only one piece per tool grind. A lubrication specialist found that the plant was using a cutting oil that was too heavy and lacked sufficient compounding. A transparent cutting oil was substituted and the same machine not only produced 20 pieces per tool grind, but the transparency of the product also enabled the operators to see their work at all times.

These specialists never know just where they will find trouble nor can they forecast the results of their inspection and study of production problems. The problems they encounter and solve frequently have baffled production experts and their work takes them into a wide variety of fields.

Efficient and proper lubrication is saving American manufacturers millions of hours of production time, Standard's industrial lubrication engineers believe. They back up this statement by reciting numerous case histories.

"Here's a typical case," they pointed out. "One of our men found a serious production delay and loss of critical material in a plant making pipe wrenches for the army and navy. The manufacturing operations called for cutting wrench jaws with circular saws. The average life of these saws was two days and one man was needed to operate four saws. By changing the lubricant the average life of the saws was increased to two weeks and one man now handles six saws."

☆ ☆ ☆

P 934.2

Analysis of Southwestern Petroleum Refinery Wages

PETROLEUM ENGINEER Exclusive Feature

☆ Results of occupational wage rate study conducted in Texas, Louisiana, and Oklahoma

by C. Wilson Randle

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A DETAILED study of 10,583 male workers in selected occupations—about 40 percent of the total labor force of 117 petroleum refineries in Texas, Oklahoma, and Louisiana — discloses that nearly four-fifths were classified in jobs that showed straight-time average hourly earnings of $1.00 or more per hr. As a group, these employees earned an average of $1.16 per hr. in April, 1943. Workers in Texas and Louisiana earned an average of $1.18 per hr. as compared with $1.05 in Oklahoma. The highest hourly earnings ($1.24) were found in the Gulf Coast area of Texas, while the corresponding average for the inland Texas area ($1.00) was the lowest. These regional differentials are, in large part, a reflection of differences in size of operation and technological processes, both of which appear to have pronounced effects on levels of earnings. Of the 34 specific occupational groups studied in detail, only 7 showed average hourly earnings below $1.00; less than a fifth of the workers covered were classified in these 7 groups. The averages for 9 occupational groups, which included more than a fourth of the workers studied, amounted to $1.25 or more per hr. The apparent upward trend of earnings in Southwestern petroleum refineries during the last 18 months is in part a reflection of the closing of disproportionate numbers of small and relatively lower wage operations as a result of changes largely occasioned by the war.

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after receiving his B.A. degree from Duke University in 1931, served in the public school system in Hickman, Kentucky, for several years—In 1935, he was employed by the Federal Emergency Relief Administration as case worker in the transient relief program in Kentucky—He compiled a research monograph on the characteristics of the transient laborer—His study of migratory labor was furthered by field work in Texas, Colorado, Washington, Oregon, and California and through graduate research at the University of Colorado—In 1938, he was employed by the Texas College of Arts and Industries, Kingsville, Texas, as associate professor of economics—After five years of teaching experience in labor problems and further graduate research at Duke University and the University of Kentucky, in December, 1942, he became regional wage analyst of the Bureau of Labor Statistics, Wage Analysis Division, Dallas regional office.

Characteristics of the Industry

According to standard trade directories, there were in operation in the United States at the close of 1942, 412 petroleum refineries with a daily crude petroleum capacity of 4,780,025 bbl. One hundred and twenty-nine of these operations with a daily capacity of 1,853,030 bbl. were located in Texas, Oklahoma, and Louisiana. Thus, 31 percent of the refineries of the United States with 39 percent of the nation's refinery capacity, were located in these three states.

The expansion of the petroleum refining industry was accompanied in peace time by the processing of such tremendous quantities of crude oil that inadequate attention was given to the effective utilization of the full range of petroleum products. This resulted in the lack of development of certain petroleum derivatives with a consequent neglect of their potentialities as sources of fuel and chemical products. Total global war, however, made extraordinary demands on the refining industry. The need for tremendous quantities of aviation gasoline and extreme service lubes for the thousands of fighting planes; the importance of breaking the explosives bottleneck by producing toluene from petroleum; the urgency of the new synthetic rubber industry, and the need for emergency technical advice for the army and navy all provided a tremendous incentive for research and development in petroleum refining. New techniques made available fuel types that would normally require years to produce. The art of oil refining has advanced so rapidly that there is little exaggeration in the statement that expensive equipment sometimes becomes obsolete almost before its construction is completed. Petroleum refining technology has expanded the oil business into a highly developed type of chemical industry.

Modern refineries may be divided into two broad types, the distillation plant and the cracking plant. Distillation is the oldest process for separating petroleum into its constituents. It is the simple physical separation of a liquid hydrocarbon into fractions with different boiling points. Distillation plants range from the simple skimming or topping plant to the operation equipped for complete distillation. Cracking is of more recent origin and involves the actual chemical rearrangement or breaking down of heavy hydrocarbons into lighter hydrocarbons and carbon. All varieties of combinations of distillation and cracking plants exist in the petroleum industry today.

In the skimming or topping plant, the gasoline and/or kerosine fractions of the crude oil are removed by a simple distillation process utilizing heat but little or no pressure. After the gasoline and kerosine fractions are removed, the remaining heavy oil is usually marketed as fuel oil. In the complete distillation plant, not only are the gasoline and kerosine fractions removed but various

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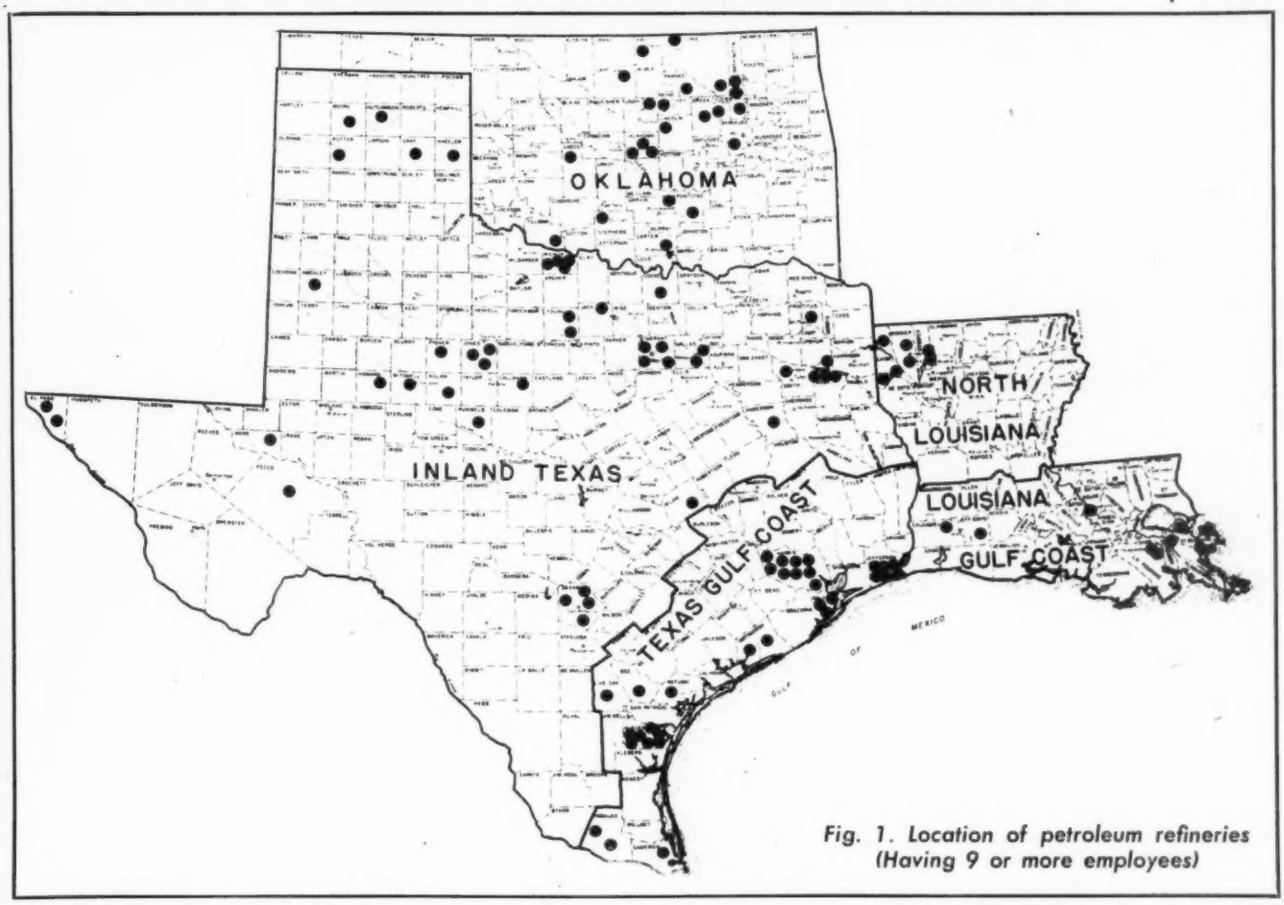

Fig. 1. Location of petroleum refineries (Having 9 or more employees)

other fractions are distilled off and refined into lubricants, greases, and other special products. Coke and/or asphalt remain as a residual product in this type of refinery operation. The complete distillation plants are usually large scale operations, whereas the skimming plants are ordinarily designed to supply local needs. It is estimated that approximately one-half of the gasoline used in peace times was derived from distillation operations.

The cracking plant utilizes a process for converting the higher into lower molecular weight hydrocarbons. This process can be accomplished by the application of heat and pressure (thermal cracking) or by the action of catalysts under conditions that give negligible thermal cracking (catalytic cracking). The catalyst not only accelerates but also directs the course of the cracking reaction to give better yields of higher quality products. It is to the improvement in "cracking" methods that much of the credit should go for the recent outstanding accomplishments of the petroleum refining industry.

Thermal cracking produces approximately half of the 600,000,000 bbl. of gasoline refined annually in the U. S. On the basis of output, it may thus be considered as the most important form of processing by cracking. On the other hand, catalytic cracking is so important in the production of such war materials as aviation gasoline, butane-butylene hydrocarbons, aromatic hydrocarbons, and butadiene that enormous impetus has been given this more recent form of cracking. At the end of 1942, according to reliable estimates, about 30,000,000 bbl. of cracked gas were being produced annually by the catalytic process, and this type of operation was being subjected to rapid extension. Today, of the 412 refineries of the U. S., 77 are equipped for catalytic cracking. Development of this type of processing is currently restricted to units of large capacity, chiefly because of the economies accruing to volume operations and the saving of steel and other critical materials.

According to trade journals, the number of operating refineries in the United States decreased by 39 during the year ended in March, 1943. The Bureau of Labor Statistics found that, from March, 1942, to September, 1943, 25 refineries in Texas, Oklahoma, and Louisiana ceased operations. Sixteen of these were in Texas, 8 in Oklahoma, and 1 in Louisiana.

The necessity for closing these plants is largely the outgrowth of conditions arising from the war program. The lack of transportation facilities for crude oil, restrictions on the use of critical materials, and the manpower problem have, in particular instances, occasioned the closing of refinery operations. In addition, the growing lack of crude oil in some sections has made operation impracticable. Contributing to this influence is the "big inch" pipe line recently completed to transport oil to the East Coast. Perhaps more important than these factors, however, is the trend toward larger refineries. Small plants employing skimming operations turn out only an inferior grade of gasoline and have a rather low recovery ratio of gasoline to crude oil processed. A further reason is found in more efficient use of critical materials in the larger refineries equipped for cracking. The Bureau of Labor Statistics found that 17 of the 25 refineries which have closed in Texas, Oklahoma, and Louisiana since March, 1942, were small operations employing skimming operations only. A decreased crude supply in combination with the demand for superior grades of petroleum products has thus been a potent combination of factors in closing the smaller and less efficient refineries.

The location of petroleum refineries is determined primarily by the most favorable combination of two factors: proximity or low-cost access to a supply of crude petroleum and the location and nature of the consuming market. One would thus expect refineries to be located near "feeder" pipe lines, railroad centers, water transportation facilities, producing fields, or large centers of

population. Reference to the distribution of refinery operations in Texas, Oklahoma, and Louisiana as shown on the accompanying map, Fig. 1, confirms such an assumption. Concentrations of refineries may be noted near Corpus Christi, Houston, Beaumont-Port Arthur, Dallas-Fort Worth, San Antonio, Wichita Falls, Shreveport, and New Orleans. Further reference to the map discloses other refineries in these states rather widely dispersed over a considerable area. In the main, these are small skimming or topping plants taking advantage of local production and catering almost exclusively to local demands.

Refining practice in various areas has been influenced by the nature of the market in which the products of the refinery are sold. For example, cracking is more important on the Gulf Coast where there is a growing demand for high octane gasoline, toluene, and butadiene for war uses than in inland areas where there is a greater demand for lower octane gasoline for motor car use or for fuel oil because of the high cost of coal. The type of crude oil produced within a region may also influence refinery operations. By way of illustration, the refining techniques utilized in processing the sweet oils of the Texas Gulf Coast would necessarily have to be modified and supplemented by additional processes if the sour crudes of West Texas were used as base stock.[1] Again, the presence of paraffin base oils might require somewhat different processing methods from those utilized for asphalt base oils. In brief, refining practices must be modified to meet the need of the type of crude petroleum being currently processed.

The various characteristics of petroleum refining as set forth in the preceding paragraphs necessarily influence wage rates and occupational structures. In general, a more skilled type of labor is required for cracking processes than for skimming or topping operations. As a consequence, wage rates show a distinct tendency to be higher in areas where there is a predominance of plants equipped for cracking than in areas where simple distillation is relatively more important. As evidence of this tendency, wage rates are significantly higher along the Gulf Coast of Texas and Louisiana where cracking plants are concentrated than in the inland areas of these states where skimming and topping are more prevalent. Large establishments, for a variety of reasons, generally pay higher wages than smaller ones. Consequently, the predominance of large refinery units within an area tends to create higher wage levels than would prevail in sections where there are greater proportions of smaller units. The presence of large refinery units in the Louisiana Gulf Coast region has doubtless contributed to the distinctly higher wage level there than in North Louisiana where the units are smaller. In this same connection, the significant number of small and relatively low-wage plants that have closed in recent months in the Southwest has probably contributed to the rise in the general level of refinery wages.

The occupational structures of petroleum refineries are also influenced by certain of the factors previously mentioned. Large plants with a more extended division of labor usually have a greater number of occupations than smaller establishments. More and different occupations are generally found in plants equipped for cracking than in plants employing only topping operations. Processing of paraffin base crudes may give rise to occupations not found in plants processing asphalt base oils. West Texas refineries utilizing "sour" crudes have different and additional occupations than Gulf Coast refineries, which process "sweet" oils. Modern refineries with a large proportion of automatic equipment use fewer employees than older type establishments. In addi-

[1]Sour crudes are usually defined as those possessing some compound of sulphur or some other ingredient that imparts corrosive characteristics to the crude petroleum stock. Sweet crudes are those that do not possess corrosive qualities.

TABLE I

Distribution of male employees in selected occupations, in the petroleum refining industry in the Southwest, according to average hourly earnings,* April, 1943

Occupation and class	No. of plants	Total workers: No. of workers	Total workers: Percent	Average hourly earnings	Number of workers in plants with specific occupational average hourly earnings: Under $0.80	$0.80 and under $0.85	$0.85 and under $0.90	$0.90 and under $0.95	$0.95 and under $1.00	$1.00 and under $1.05	$1.05 and under $1.10	$1.10 and under $1.15	$1.15 and under $1.20	$1.20 and under $1.25	$1.25 and under $1.30	$1.30 and under $1.35	$1.35 and under $1.40	$1.40 and over
All workers: Number	....	10,583	....	....	723	196	245	365	599	625	738	471	858	1,724	631	1,233	824	1,351
Percent	....	....	100.0	....	6.8	1.9	2.3	3.4	5.7	5.9	7.0	4.5	8.1	16.3	6.0	11.6	7.8	12.7
Carpenters, class A	26	124	1.2	$1.32	.....	.....	.....	.....	2	.....	5	.....	16	1	14	7	37	42
Carpenters, class B	16	58	0.5	1.15	.....	1	3	.....	.....	4	1	2	40	4	1	2	.....	.....
Centrifuge operators	11	75	0.7	1.27	.....	.....	.....	.....	.....	4	13	.....	.....	4	4	32	.....	18
Chillermen	11	50	0.5	1.23	.....	.....	.....	5	.....	.....	8	.....	.....	17	.....	.....	15	5
Compounders	17	57	0.5	1.21	1	.....	1	.....	2	3	3	17	1	7	1	3	11	7
Electricians, class A	44	221	2.1	1.37	.....	.....	.....	1	2	1	3	4	7	2	17	30	33	121
Electricians, class B	28	102	1.0	1.18	1	.....	2	1	.....	12	1	1	19	40	11	14	.....	.....
Filtermen	15	93	0.9	1.19	.....	4	.....	5	.....	9	.....	11	4	17	15	21	7	.....
Firemen, stills	50	536	5.1	1.13	23	.....	10	8	31	22	17	48	108	257	9	.....	3	.....
Guards	42	463	4.4	0.93	76	4	39	22	114	107	101	.....	.....	.....	.....	.....	.....	.....
Janitors	49	183	1.7	0.78	76	38	1	66	2	.....	.....	.....	.....	.....	.....	.....	.....	.....
Machinists, class A	50	460	4.3	1.36	.....	.....	.....	.....	2	4	1	2	16	11	25	64	178	157
Machinists, class B	36	251	2.4	1.18	2	.....	.....	6	.....	11	4	6	73	149	.....	.....	.....	.....
Packers, hand or machine	14	90	0.8	0.90	15	5	25	5	12	3	25	.....	.....	.....	.....	.....	.....	.....
Pipefitters, class A	49	319	3.0	1.32	.....	.....	1	.....	6	3	5	8	27	9	43	52	91	74
Pipefitters, class B	38	307	2.9	1.15	12	4	4	13	5	5	3	39	32	161	29	.....	.....	.....
Pressmen, paraffin	12	122	1.2	1.11	.....	16	.....	8	12	15	.....	5	4	34	.....	28	.....	.....
Pumpmen	80	858	8.1	1.22	39	19	22	21	11	50	35	32	23	22	39	378	120	47
Pumpmen helpers	29	471	4.5	1.15	22	4	1	3	19	11	14	41	230	76	50	.....	.....	.....
Routine testers, laboratory	77	681	6.4	1.07	52	18	11	52	76	20	116	47	4	279	.....	1	5	.....
Stillmen, cracking	65	463	4.4	1.36	2	.....	.....	10	11	15	11	23	18	22	4	64	29	254
Stillmen, other	93	712	6.7	1.25	66	15	12	16	21	19	8	30	26	75	40	15	54	315
Stillmen helpers No. 1	66	988	9.3	1.19	28	21	6	9	19	27	122	36	67	183	263	183	.....	24
Stillmen helpers No. 2	41	410	3.9	1.13	35	4	5	20	16	5	21	25	50	101	.....	120	8	.....
Stock clerks	46	125	1.2	0.98	28	10	16	2	5	11	13	6	5	2	2	23	.....	2
Treaters	77	393	3.7	1.24	15	7	12	10	3	44	10	7	42	19	24	10	95	95
Treaters' helpers	34	313	3.0	1.17	15	.....	2	30	7	3	17	12	3	93	29	102	.....	.....
Truck drivers, under 2½ tons	48	227	2.1	0.90	48	1	43	10	20	64	8	32	.....	.....	.....	.....	1	.....
Truck drivers, 2½ tons and over	34	198	1.9	0.92	47	6	3	7	8	74	30	23	.....	.....	.....	.....	.....	.....
Watchmen	38	481	4.5	0.93	106	14	25	29	175	43	89	.....	.....	.....	.....	.....	.....	.....
Wax operators	9	45	0.4	1.17	.....	.....	.....	.....	.....	7	.....	9	1	20	.....	8	.....	.....
Welders, hand (gas and arc), class A	62	460	4.3	1.34	.....	.....	.....	2	.....	5	6	4	17	66	9	76	136	139
Welders, hand (gas and arc), class B	36	155	1.5	1.09	6	5	.....	4	11	22	32	1	21	51	2	.....	.....	.....
Working foremen, processing departments	31	92	0.9	1.26	8	.....	1	.....	7	2	16	.....	4	2	.....	.....	1	51

*Exclusive of premium payments for overtime and night shift work.

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tion, these employees tend to have more varied duties than those in older types of refineries where the equipment being utilized enforces strict division of labor. The same tendency is also apparent in the smaller refineries where several jobs may be done by one employee. Apparently in both the more modern refineries and in the smaller refineries there appears to be no strict adherence to a very fine division of labor.

Practices and characteristics of the petroleum refining industry thus appear to be significant influences with regard to the level of wages, the occupational structure of the industry and, to a lesser extent, to the method of labor utilization.

Scope and Method of Survey

This survey of wages paid in the petroleum refining industry in the Southwest was undertaken by the Bureau of Labor Statistics as part of its program of procuring basic wage information for use in the wage stabilization program.[2] Included in the survey were 33,923 employees in 117 refineries located in Texas, Oklahoma, and Louisiana. These establishments represent all the petroleum refineries in these states with 9 or more employees and operating in April, 1943, the time of the survey.[2] Of the refineries studied, 78 employing 20,626 persons were situated in Texas, 23 employing 5,131 workers were found in Oklahoma, and 16 refineries employing 8,166 workers were in Louisiana. Detailed wage information was obtained for 34 selected plant occupations covering 10,583 workers or approximately 40 percent of the total plant employment.

[2]Reports of earlier studies of this industry made by the Bureau in 1920 and 1934 may be found in the *Monthly Labor Review*, May, 1921, pp. 50-52, and August, 1922, pp. 87-88; July, 1935, pp. 13-37, and November, 1935, pp. 1105-1119.

TABLE 3

Average hourly earnings of male workers in selected occupations in the petroleum refining industry in the Southwest, by area, April, 1943*

Area	Average hourly earnings
Southwest	$1.16
Oklahoma	1.05
Louisiana	1.18
North Louisiana	1.06
Gulf Coast	1.22
Texas	1.18
Inland	1.00
Gulf Coast	1.24

*All data are exclusive of premiums for overtime and night-shift work. Individual area averages based on constant occupational weights as shown in Table 1.

No attempt was made to cover all occupations found in the petroleum refining industry. The intent was to cover such key occupations as would adequately represent the wage structure of the industry. The choice of occupations was guided by consideration of the following criteria: (1) Stability and definiteness of the occupation. (2) Strategic importance from the standpoint of collective bargaining. (3) Numerical importance. (4) Critical importance from the standpoint of war effort. (5) Representativeness of the range of earnings. Needless to say, the occupations selected do not satisfy all these requirements equally well. Considered as a whole, however, they are believed to provide an adequate picture of the wage structure.

The majority of refineries in the Southwest work a partial or skeleton night and swing shift. This tendency has become increasingly evident as the pressure of war demands has impelled longer producing hours. Any differential amount that is paid for such shifts, has been excluded from the data. Extra earnings from premium pay for overtime were also eliminated.[3] As a result, the average earnings presented in this report are straight-time hourly earnings, exclusive of premium overtime and shift-differential payments. It should also be emphasized that the averages shown are occupational averages and do not necessarily reflect the range of earnings of individual workers.

The wage data were taken from pay roll and other plant records by experienced representatives of the Bureau of Labor Statistics, who used a standard set of occupational definitions in classifying the employees of each company studied.[4]

Refining Regions

For purposes of indicating wage dif-

[3]With negligible exceptions, time and one-half after 40 hours a week or 8 hours a day was paid by Southwest petroleum refineries. Incentive systems are nonexistent in the petroleum refining industry of the Southwest and consequently all wages shown are actually hourly wage rates.

[4]Copies of the occupational descriptions used in this study are available for review in the Dallas regional wage office of the Bureau.

TABLE 2

Average hourly earnings,* of male workers in selected occupations, petroleum refining in the Southwest, April, 1943

Occupation and class	No. of plants	No. of workers	Hourly earnings		
			General average	Lowest plant average	Highest plant average
Carpenters, class A	26	124	$1.32	$0.95	$1.44
Carpenters, class B	16	58	1.15	0.80	1.30
Centrifuge operators	11	75	1.27	1.03	1.42
Chillermen	11	50	1.23	0.94	1.42
Compounders	17	57	1.21	0.78	1.43
Electricians, class A	44	221	1.37	0.94	1.50
Electricians, class B	28	102	1.18	0.76	1.32
Filtermen	15	93	1.19	0.80	1.36
Firemen, stills	50	536	1.13	0.58	1.35
Guards	42	463	0.93	0.33	1.08
Janitors	49	183	0.78	0.30	0.95
Machinists, class A	50	460	1.36	0.95	1.50
Machinists, class B	36	251	1.18	0.75	1.24
Packers, hand or machine	14	90	0.90	0.45	1.08
Pipefitters, class A	49	319	1.32	0.89	1.50
Pipefitters, class B	38	307	1.15	0.40	1.29
Pressmen, paraffin	12	122	1.11	0.81	1.30
Pumpmen	80	858	1.22	0.44	1.45
Pumpmen helpers	29	471	1.15	0.45	1.28
Routine testers, laboratory	77	681	1.07	0.40	1.37
Stillmen, cracking	65	463	1.36	0.74	1.55
Stillmen, other	93	712	1.25	0.46	1.60
Stillmen helpers No. 1	66	988	1.19	0.40	1.51
Stillmen helpers No. 2	41	410	1.13	0.35	1.38
Stock clerks	46	125	0.98	0.47	1.71
Treaters	77	393	1.24	0.50	1.56
Treaters' helpers	34	313	1.17	0.40	1.34
Truck drivers, under 2½ tons	48	227	0.90	0.36	1.39
Truck drivers, 2½ tons and over	34	198	0.92	0.35	1.14
Watchmen	38	481	0.93	0.34	1.08
Wax operators	9	45	1.17	1.00	1.30
Welders, hand (gas and arc), class A	62	460	1.34	0.90	1.50
Welders, hand (gas and arc), class B	36	155	1.09	0.49	1.26
Working foremen, processing departments	31	92	1.26	0.67	1.73

*Exclusive of premium payments for overtime and night shift work.

TABLE 4

Average hourly earnings,* of male workers in selected occupations, petroleum refining industry, Oklahoma, April, 1943

Occupation and class	No. of plants	No. of workers	Hourly earnings		
			General average	Lowest plant average	Highest plant average
Carpenters, class A	5	21	$1.19	$1.05	$1.26
Carpenters, class B	3	3	0.94	0.88	1.05
Centrifuge operators	6	25	1.15	1.03	1.30
Chillermen	5	26	1.15	0.94	1.42
Compounders	7	24	1.09	0.96	1.26
Electricians, class A	11	27	1.26	1.08	1.42
Electricians, class B	7	8	0.98	0.76	1.12
Filtermen	7	36	1.15	1.00	1.30
Firemen, stills	15	108	1.04	0.72	1.17
Guards	11	48	0.88	0.59	1.00
Janitors	11	27	0.80	0.50	0.95
Machinists, class A	15	35	1.21	1.00	1.34
Machinists, class B	11	35	1.10	0.75	1.18
Packers, hand or machine	5	38	0.90	0.72	0.98
Pipefitters, class A	12	52	1.17	0.89	1.26
Pipefitters, class B	6	63	1.12	0.94	1.16
Pressmen, paraffin	6	37	1.01	0.92	1.17
Pumpmen	18	105	1.05	0.67	1.30
Pumpmen helpers	4	19	0.95	0.68	1.06
Routine testers, laboratory	17	120	0.98	0.61	1.24
Stillmen, cracking	20	113	1.21	0.92	1.48
Stillmen, other	20	134	1.16	0.70	1.42
Stillmen helpers No. 1	15	128	1.08	0.60	1.26
Stillmen helpers No. 2	10	61	0.97	0.72	1.15
Stock clerks	14	35	0.88	0.63	1.71
Treaters	21	81	1.08	0.76	1.32
Treaters' helpers	7	36	0.94	0.69	1.09
Truck drivers, under 2½ tons	13	47	0.83	0.61	1.05
Truck drivers, 2½ tons and over	12	40	0.88	0.50	1.14
Watchmen	11	104	0.78	0.50	0.92
Wax operators	5	26	1.13	1.00	1.24
Welders, hand (gas and arc), class A	19	97	1.22	1.00	1.45
Welders, hand (gas and arc), class B	12	63	1.08	0.80	1.26
Working foremen, processing departments	4	28	1.39	0.99	1.49

*Exclusive of premium payments for overtime and night shift work.

TABLE 5

Average hourly earnings,* of male workers in selected occupations, petroleum refining industry, Louisiana, April, 1943

Occupation and class	State					North Louisiana					Gulf Coast				
	No. of plants	No. of workers	Hourly earnings			No. of plants	No. of workers	Hourly earnings			No. of plants	No. of workers	Hourly earnings		
			General average	Lowest plant average	Highest plant average			General average	Lowest plant average	Highest plant average			General average	Lowest plant average	Highest plant average
Carpenters, class A	5	47	$1.38	$1.24	$1.40	†	†	†	†	†	4	46	$1.38	$1.26	$1.40
Carpenters, class B	3	40	1.17	1.00	1.18	†	†	†	†	†	2	39	1.17	†	†
Compounders	3	4	1.22	0.87	1.43	†	†	†	†	†	2	3	1.34	†	†
Electricians, class A	8	48	1.41	1.15	1.44	3	3	1.29	1.24	1.33	5	45	1.42	1.15	1.44
Electricians, class B	3	16	1.29	1.00	1.32						3	16	1.29	1.00	1.32
Firemen, stills	7	73	1.14	0.90	1.23	†	†	†	†	†	5	64	1.16	0.90	1.20
Guards	6	43	0.89	0.53	0.95	3	15	0.81	0.53	0.91	3	28	0.93	0.65	0.95
Janitors	6	14	0.64	0.37	0.80	3	6	0.50	0.37	0.60	3	8	0.75	0.45	0.80
Machinists, class A	7	89	1.40	1.00	1.42	3	4	1.25	1.00	1.33	4	85	1.41	1.25	1.42
Machinists, class B	3	46	1.18	1.00	1.18	†	†	†	†	†	†	†	†	†	†
Pipefitters, class A	8	34	1.29	1.18	1.40	3	6	1.31	1.24	1.33	5	28	1.29	1.18	1.40
Pipefitters, class B	8	25	1.00	0.65	1.26	†	†	†	†	†	6	22	0.98	0.65	1.26
Pumpmen	12	106	1.18	0.60	1.44	5	20	1.02	0.70	1.23	7	86	1.22	0.60	1.44
Pumpmen helpers	3	61	1.20	0.99	1.26	†	†	†	†	†	†	†	†	†	†
Routine testers, laboratory	12	141	1.13	0.40	1.23	5	17	0.94	0.71	1.21	7	124	1.16	0.40	1.23
Stillmen, cracking	7	80	1.43	1.00	1.50	3	16	1.40	1.33	1.45	4	64	1.44	1.00	1.50
Stillmen, other	14	150	1.36	0.46	1.50	7	33	1.12	0.80	1.33	7	117	1.43	0.46	1.50
Stillmen helpers No. 1	6	93	1.23	0.81	1.29	3	22	1.07	0.81	1.17	3	71	1.28	1.27	1.29
Stillmen helpers No. 2	4	59	1.15	0.60	1.22	†	†	†	†	†	3	44	1.17	0.60	1.22
Stock clerks	5	8	1.04	0.81	1.24	†	†	†	†	†	4	6	1.05	0.81	1.24
Treaters	8	45	1.23	0.80	1.49	4	21	1.15	0.89	1.23	4	24	1.31	0.80	1.49
Treaters' helpers	4	34	1.06	0.40	1.29	†	†	†	†	†	3	28	1.09	0.40	1.29
Truck drivers, under 2½ tons	6	17	0.67	0.36	0.96	†	†	†	†	†	4	11	0.72	0.36	0.96
Watchmen	5	52	0.94	0.34	1.04	†	†	†	†	†	4	45	0.96	0.34	1.04
Welders, hand (gas & arc), class A	6	80	1.41	1.10	1.44	4	5	1.23	1.10	1.33	2	75	1.42	†	†
Welders, hand (gas & arc), class B	3	3	1.14	1.00	1.25	†	†	†	†	†	†	†	†	†	†
Working foremen, processing departments	3	3	1.70	1.67	1.73	†	†	†	†	†	†	†	†	†	†

*Exclusive of premium payments for overtime and night shift work.
†Number of plants and/or workers too small to justify presentation of an average.

ferentials, the Gulf Coast areas of both Texas and Louisiana have been tabulated separately in this study. This is not intended to imply that geographical considerations are a primary causal factor in wage differentials. Such wage differentials as are existent in petroleum refining in the Southwest are apparently due more to size of establishment and processing method than to geographical influences. Proximity to a source of crude oil and to cheap transportation facilities has resulted in the location of the larger refineries along the Gulf Coast. The location of larger plants in this area has been accompanied by more intricate processing methods requiring a more skilled type of labor. It thus becomes possible to draw regional distinctions that are in reality distinctions as to size of establishment and type of process rather than mere lines of geographical demarcation.

The Labor Force

The majority of occupations in petroleum refineries require a high degree of skill, which can ordinarily be acquired only after a considerable period of experience. As technological advance

TABLE 6

Average hourly earnings,* of male workers in selected occupations in the petroleum refining industry in Texas, April, 1943

Occupation and class	State					Inland					Gulf Coast				
	No. of plants	No. of workers	Hourly earnings			No. of plants	No. of workers	Hourly earnings			No. of plants	No. of workers	Hourly earnings		
			General average	Lowest plant average	Highest plant average			General average	Lowest plant average	Highest plant average			General average	Lowest plant average	Highest plant average
Carpenters, class A	16	56	$1.33	$0.95	$1.44	8	14	$1.18	$0.95	$1.34	8	42	$1.38	$1.32	$1.44
Carpenters, class B	10	15	1.14	0.80	1.30	5	6	1.07	0.80	1.25	5	9	1.18	0.88	1.30
Centrifuge operators	4	32	1.28	1.07	1.32	†	†	†	†	†	3	28	1.31	1.30	1.32
Chillermen	5	20	1.33	1.22	1.37						5	20	1.33	1.22	1.37
Compounders	7	29	1.30	0.78	1.42	†	†	†	†	†	6	27	1.31	0.78	1.42
Electricians, class A	25	146	1.38	0.94	1.50	11	18	1.19	0.97	1.34	14	128	1.40	0.94	1.50
Electricians, class B	18	78	1.18	0.86	1.25	8	14	1.00	0.90	1.25	10	64	1.20	0.86	1.25
Filtermen	6	43	1.25	0.92	1.36	†	†	†	†	†	5	38	1.29	1.20	1.36
Firemen, stills	28	355	1.16	0.58	1.35	14	57	1.01	0.58	1.35	14	298	1.19	0.60	1.26
Guards	25	372	0.94	0.33	1.08	10	76	0.86	0.50	1.03	15	296	0.97	0.33	1.08
Janitors	32	142	0.79	0.30	0.93	15	29	0.60	0.30	0.78	17	113	0.84	0.44	0.93
Machinists, class A	28	336	1.36	0.95	1.50	12	28	1.23	0.95	1.34	16	308	1.38	1.20	1.50
Machinists, class B	22	170	1.20	0.75	1.24	11	21	1.05	0.75	1.17	11	149	1.22	1.20	1.24
Packers, hand or machine	8	51	0.89	0.45	1.08	6	26	0.72	0.45	1.02	†	†	†	†	†
Pipefitters, class A	29	233	1.36	0.96	1.50	14	26	1.19	0.97	1.44	15	207	1.39	0.96	1.50
Pipefitters, class B	24	219	1.17	0.40	1.29	13	33	0.89	0.40	1.17	11	186	1.22	0.88	1.29
Pressmen, paraffin	5	77	1.14	0.81	1.30	†	†	†	†	†	4	74	1.15	0.84	1.30
Pumpmen	50	647	1.25	0.44	1.45	29	123	1.01	0.44	1.30	21	524	1.31	0.67	1.45
Pumpmen helpers	22	391	1.15	0.45	1.28	11	36	0.83	0.45	1.12	11	355	1.18	0.95	1.28
Routine testers, laboratory	48	420	1.08	0.48	1.37	25	101	0.92	0.48	1.10	23	319	1.14	0.66	1.37
Stillmen, cracking	38	270	1.40	0.74	1.55	24	109	1.28	0.96	1.51	14	161	1.48	0.74	1.55
Stillmen, other	59	428	1.24	0.47	1.60	32	145	1.04	0.48	1.60	27	283	1.35	0.47	1.53
Stillmen helpers No. 1	45	767	1.20	0.40	1.51	26	196	1.03	0.40	1.30	19	571	1.26	0.63	1.51
Stillmen helpers No. 2	27	290	1.16	0.35	1.38	14	86	0.99	0.35	1.20	13	204	1.23	0.37	1.38
Stock clerks	27	82	1.02	0.47	1.56	14	22	0.90	0.47	1.29	13	60	1.06	0.52	1.56
Treaters	48	267	1.29	0.50	1.56	29	80	1.08	0.56	1.32	19	187	1.38	0.50	1.56
Treaters' helpers	23	243	1.22	0.46	1.34	9	24	0.97	0.65	1.32	14	219	1.25	0.46	1.34
Truck drivers, under 2½ tons	29	163	0.94	0.40	1.39	16	49	0.79	0.40	1.39	13	114	1.01	0.44	1.14
Truck drivers, 2½ tons and over	21	155	0.93	0.35	1.12	13	38	0.58	0.35	0.96	8	117	1.04	0.68	1.12
Watchmen	22	325	0.97	0.50	1.08	10	47	0.85	0.50	0.96	12	278	0.99	0.50	1.08
Wax operators	4	19	1.23	1.12	1.30	†	†	†	†	†	3	15	1.26	1.23	1.30
Welders, hand (gas & arc), class A	37	283	1.36	0.90	1.50	16	25	1.23	0.90	1.38	21	258	1.37	0.94	1.50
Welders, hand (gas & arc), class B	21	89	1.10	0.49	1.22	13	35	0.97	0.49	1.17	8	54	1.18	0.72	1.22
Working foremen, processing departments	24	61	1.18	0.67	1.73	14	32	1.13	0.74	1.73	10	29	1.24	0.67	1.51

*Exclusive of premium payments for overtime and night shift work.
†Number of plants and/or workers too small to justify presentation of an average.

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is made in the industry and processes become more complex, an even greater premium is placed upon experience and skill. Efforts have been made, therefore, to reduce labor turnover to an absolute minimum. Personnel policies, high wage rates, and the obviously essential character of the work have contributed to the success of this endeavor. It may be noted in this connection that the petroleum refining industry in this area has not experienced the wholesale influx of women workers that has characterized other industries. Even in the face of a serious manpower shortage, the survey disclosed that less than 1 percent of the total number of plant employees found in selected occupations were women.[5] Furthermore, all female employees were working as janitresses, routine testers, and stock clerks. This indicates that such women as are employed in plant occupations in this area are primarily in jobs requiring comparatively little skill. It is true, however, that women are being hired in increasing numbers.[6] The majority of these workers are being utilized in the offices of the refineries. The Bureau of Labor Statistics found approximately 74 percent of refinery office forces are composed of women.

The greatest employee concentration was found in the occupational classifications of stillmen helpers, No. 1; stillmen, other, and pumpmen. This could be expected as not only are these workers needed in appreciable numbers but the occupational classifications mentioned are common to practically all refineries. The smallest number of employees were found in the occupational classifications of compounders, chillermen, and wax operators. This was also to be expected. Compounder is a somewhat unusual occupational classification and is seldom found except in the largest refineries. Chillermen and wax operators are commonly found only where paraffin exists in the crude petroleum base stock. There is little paraffin to be found in southwestern crudes.

The Southwest is generally regarded as being one of the less unionized sections of the United States. This generalization, however, does not appear strictly applicable to the petroleum refining industry of this area. Of the 117 companies scheduled employing some 33,923 workers, 28,491 employees or 84 percent of the total were in companies having union agreements with their employees. Of the 28,491 employees in union companies, 15,026 or approximately 53 percent were under agreements with unions affiliated with either the C. I. O. or A. F. of L.,[7] whereas 13,465 or about 47 percent were in companies possessing agreements with independent unions of various types.

As could be expected, the larger refineries of the Southwest were more highly unionized than the smaller establishments. Evidence of this may be seen in the fact that the 58 union plants surveyed contained 84 percent of the total refinery employment, whereas the 59 non-union establishments employed only 16 percent of the total working force of refineries in the Southwest. Almost 91 percent of the refinery employees of Oklahoma were in companies possessing union agreements, whereas about 85 percent of Texas refinery employees and 78 percent of Louisiana employees were in union plants.

Avg. Hourly Earnings, April, 1943

Indicative of the high level of wages prevailing in the petroleum refining industry is the fact that, of the 10,583 workers studied, who constitute 40 percent of plant employees in these operations, only about 14.0 percent received less than 95 cents an hr., (Table 1). On

[5]Because of the negligible number of women employees in plant occupations and because of their wide dispersion through so many plants, they have been excluded from the averages shown for plant occupations.

[6]See "Employment of Women in Petroleum Refineries," *Monthly Labor Review*, August, 1943, p. 197.

[7]Affiliation was with the International Oil Workers Union, C. I. O., and the International Union of Operating Engineers, an A. F. of L. union.

(Continued on Page 112)

TABLE 7

Average hourly earnings,* of male workers in selected occupations, by size of plant, petroleum refining in the Southwest, April, 1943

Occupation and class	Small plants (9-50 employees)		Medium plants (51-250 employees)		Larger plants (251 or more employees)	
	No. of employees	Average hourly earnings	No. of employees	Average hourly earnings	No. of employees	Average hourly earnings
Carpenters, class A	†	†	20	$1.25	103	$1.34
Carpenters, class B	†	†	6	1.00	51	1.17
Centrifuge operators			8	1.06	67	1.30
Chillermen			5	0.94	45	1.26
Compounders	†	†	4	1.08	52	1.22
Electricians, class A	†	†	30	1.22	190	1.40
Electricians, class B	†	†	16	1.06	85	1.21
Filtermen	....	....	14	0.93	79	1.23
Firemen, stills	19	0.79	141	1.05	376	1.18
Guards	12	0.60	150	0.80	301	1.01
Janitors	13	0.41	46	0.69	124	0.85
Machinists, class A	†	†	48	1.26	409	1.37
Machinists, class B	†	†	28	1.06	220	1.20
Packers, hand or machine	7	0.80	20	0.69	63	0.97
Pipefitters, class A	4	1.20	61	1.22	254	1.35
Pipefitters, class B	12	0.70	46	0.97	249	1.20
Pressmen, paraffin	....	....	8	0.99	114	1.12
Pumpmen	60	0.75	202	1.11	596	1.30
Pumpmen, helpers	12	0.73	58	0.95	401	1.19
Routine testers, laboratory	22	0.84	179	0.93	480	1.14
Stillmen, cracking	39	1.08	157	1.29	267	1.44
Stillmen, other	157	0.89	130	1.18	425	1.41
Stillmen helpers No. 1	57	0.74	139	1.12	792	1.23
Stillmen helpers No. 2	26	0.49	123	1.06	261	1.22
Stock clerks	17	0.59	43	0.92	65	1.12
Treaters	32	0.85	126	1.12	235	1.36
Treaters' helpers	8	0.78	49	0.95	256	1.23
Truck drivers, under 2½ tons	38	0.50	53	0.90	136	1.01
Truck drivers, 2½ tons and over	30	0.50	37	0.83	131	1.04
Watchmen	16	0.56	101	0.83	364	0.97
Wax operators	....	....	14	1.16	31	1.18
Welders, hand (gas and arc), class A	7	1.15	64	1.27	389	1.35
Welders, hand (gas and arc), class B	9	0.79	32	0.99	114	1.14
Working foremen, processing departments	17	0.90	37	1.20	38	1.45

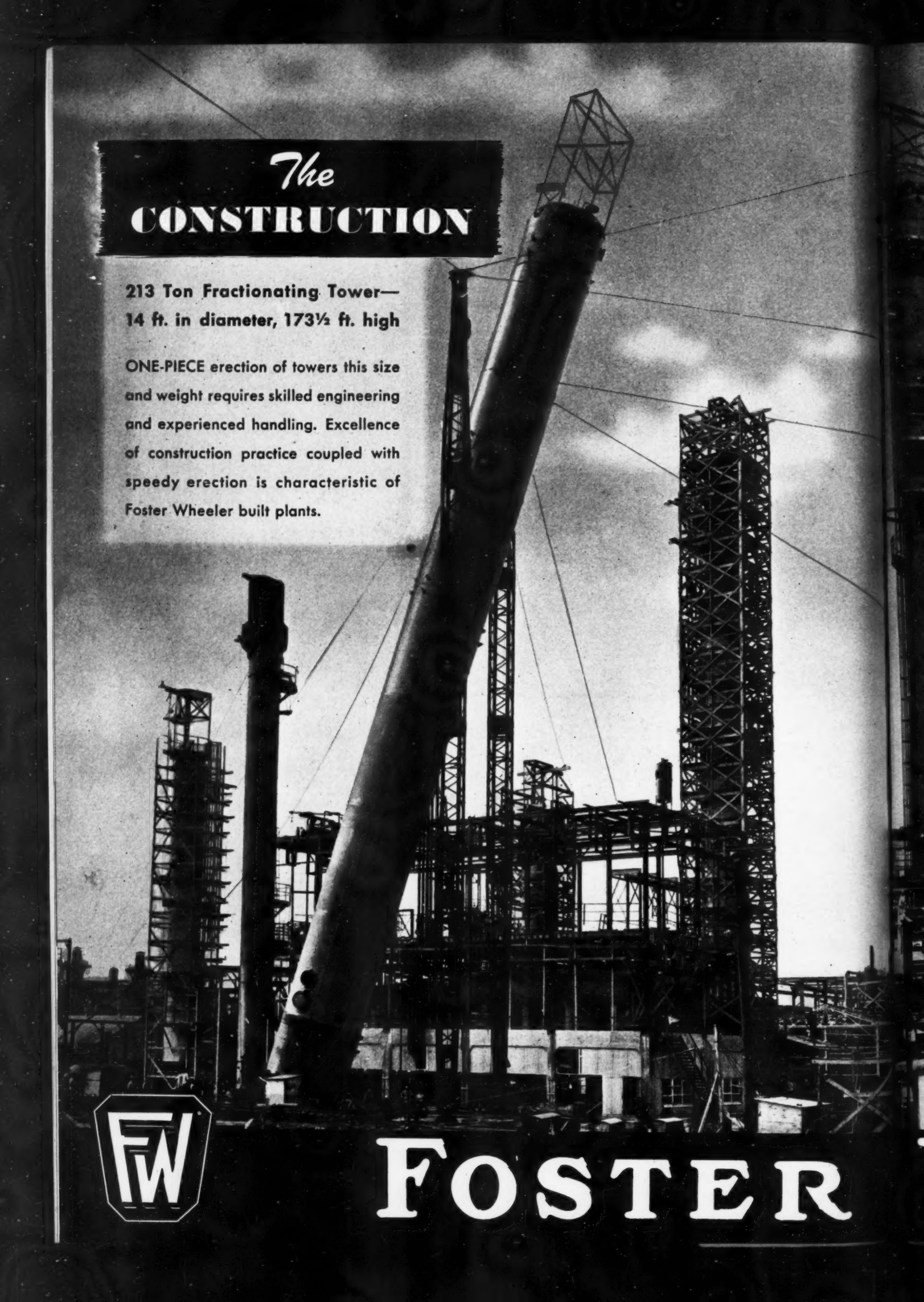
*Exclusive of premium payments for overtime and night shift work.
†Number of workers too small to justify presentation of an average.

TABLE 8

Average hourly earnings,* of male workers in selected occupations in petroleum refining plants possessing cracking units in comparison with other refineries in the Southwest, April, 1943

Occupation, and class,	Refineries possessing cracking units		Other refineries	
	No. of workers	Average hourly earnings	No. of workers	Average hourly earnings
Carpenters, class A	120	$1.33	4	$1.29
Carpenters, class B	52	1.16	6	1.08
Centrifuge operators	75	1.27	....	....
Chillermen	50	1.23	....	....
Compounders	55	1.21	†	†
Electricians, class A	216	1.37	5	1.20
Electricians, class B	101	1.18	†	†
Filtermen	89	1.20	4	0.80
Firemen, stills	518	1.15	18	0.78
Guards	447	0.94	16	0.64
Janitors	171	0.81	12	0.45
Machinists, class A	451	1.36	9	1.29
Machinists, class B	247	1.18	4	1.22
Packers, hand or machine	88	0.90	†	†
Pipefitters, class A	311	1.33	8	1.29
Pipefitters, class B	291	1.17	16	0.79
Pressmen, paraffin	122	1.11	....	....
Pumpmen	798	1.25	60	0.85
Pumpmen helpers	452	1.15	19	0.91
Routine testers, laboratory	634	1.09	47	0.91
Stillmen, cracking	463	1.36	....	....
Stillmen, other	561	1.34	151	0.91
Stillmen helpers No. 1	947	1.21	41	0.76
Stillmen helpers No. 2	388	1.16	22	0.60
Stock clerks	106	1.02	19	0.73
Treaters	367	1.27	26	0.81
Treaters' helpers	304	1.19	9	0.62
Truck drivers, under 2½ tons	188	0.97	39	0.57
Truck drivers, 2½ tons and over	182	0.95	16	0.60
Watchmen	465	0.93	16	0.62
Wax operators	45	1.18	....	....
Welders, hand (gas and arc), class A	446	1.34	14	1.28
Welders, hand (gas and arc), class B	150	1.10	5	0.84
Working foremen, processing departments	79	1.27	13	1.20

*Exclusive of premium payments for overtime and night shift work.
†Number of workers too small to justify presentation of an average.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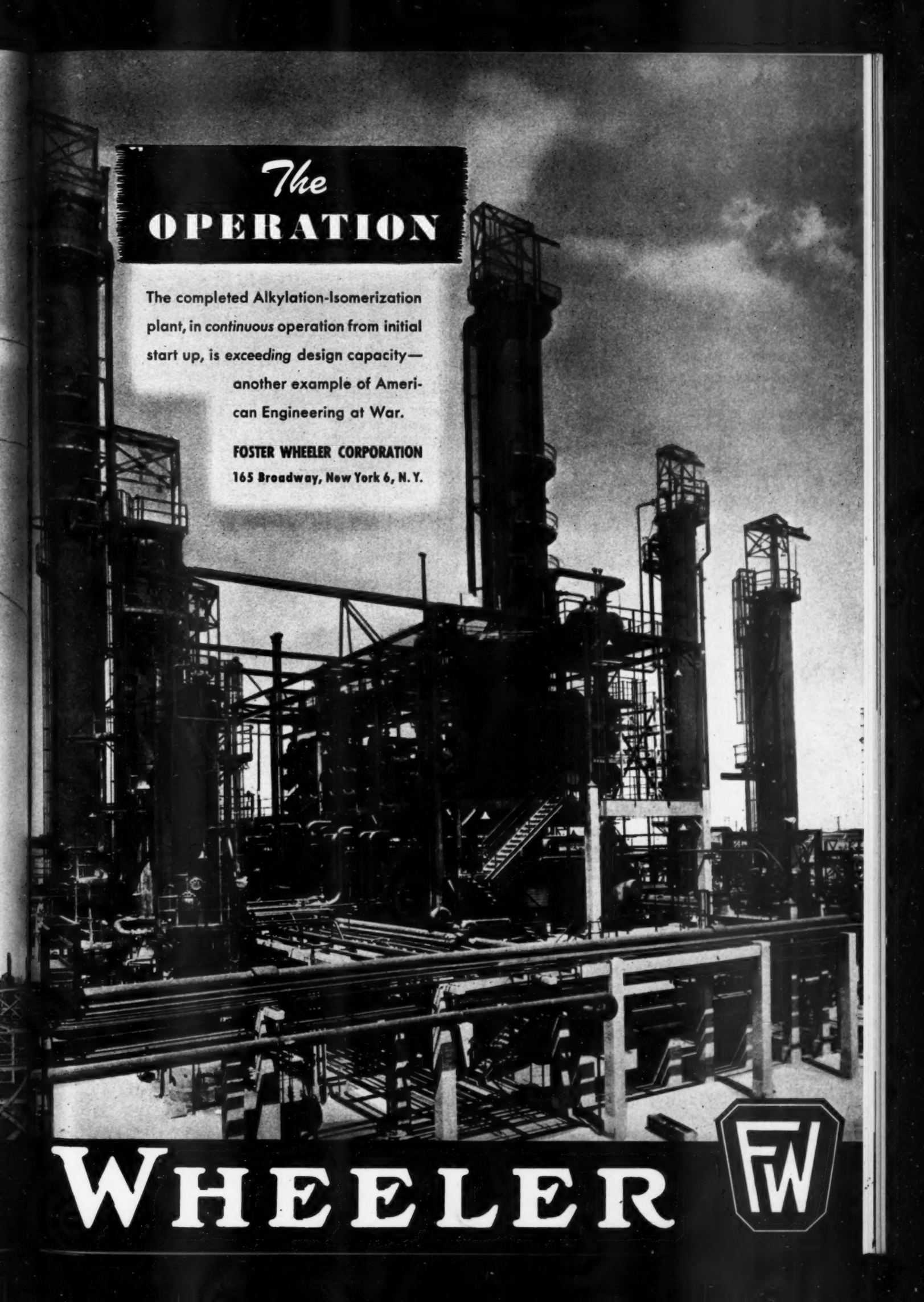
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(Continued from Page 109)

the other hand, approximately 55 percent received more than $1.15 an hr., and 22 percent received more than $1.25 an hr. Thirty percent of the plant employees surveyed were grouped in the wage range from $1.15 to $1.30 an hr. and 50 percent in the range from $1.15 to $1.40 an hr. These rates in comparison with other data accumulated from comprehensive Bureau of Labor Statistics wage surveys in the Southwest indicate that the level of wages prevailing in the petroleum refining industry is substantially higher than those in the majority of other industries in this area.

Occupational Differences

The averages for individual occupations ranged from 78 cents an hr. for janitors to $1.37 for class A electricians. Of the 34 occupational groups studied, only 7 showed average earnings below $1.00 per hr.; approximately 17 percent of the workers covered were classified in these groups. At the other end of the distribution were 9 occupational groups, which included more than a fourth (28 percent) of the workers, with averages of $1.25 or more per hr. A little more than half the workers in these higher paid groups were doing maintenance work; included were class A carpenters, electricians, machinists, pipefitters, and hand welders.

Substantial interplant variations in wage rates are apparent in the ranges shown in Table 2. These ranges reflect differences in location, size and type of operation, unionization, and other plant characteristics that are frequently associated with variations in wage levels. These factors are discussed in greater detail below. It should be noted that the lowest and highest averages shown in Table 2 are plant averages and do not necesssarily reflect the full range of the earnings of individual workers.

Regional Differences

The average straight-time earnings of plant employees in the 117 petroleum refineries included in the survey amounted to $1.16 in April, 1943 (Table 3). Further breakdown of this large area discloses significant regional variations in hourly earnings in the industry.[8] On a state-wide basis, wage earners in Texas and Louisiana showed as an average for the occupations covered $1.18 an hr. compared with $1.05 an hr. in Oklahoma. More detailed area breakdowns show that the highest average hourly

[8]Regional and state averages in Table 3 were computed by using constant employee weights. This method of weighing prevents distortion of area averages by differences in occupational structure.

TABLE 9

Petroleum refineries in the Southwest, April, 1943 (Having 9 or more employees)

Name	Location	Approximate crude petroleum capacity (bbl. per day)	Product code*
Texas			
Amsco Refining Co	Corpus Christi	10,000	S
Atlantic Refining Co	Atreco	23,900	S-C
Baird Refining Co	Baird	2,000	S-C
Bryson Pipe Line and Refining Co	Bryson	2,500	S-L
Coastal Refineries, Inc	Port Isabel	6,500	S-C
Col-Tex Refinery Co	Colorado City	10,000	S-C-A
Continental Oil Co	Wichita Falls	5,000	S-C
Cosden Petroleum Corp	Big Spring	16,000	S-C
Cosden Petroleum Corp	Graham	2,500	S
Crown Central Petroleum Corp	Pasadena	16,000	S-C-L
Danciger Oil and Refineries, Inc	Pampa	7,000	S-C
Eastern States Petroleum Co., Inc	Houston	15,000	S-C
Gladewater Refining Co	Gladewater	3,000	S-C
Gratex Refining and Fuel Oil Co	Graham	500	S
Gulf Oil Corp	Fort Worth	7,500	S-C
Gulf Oil Corp	Port Arthur	153,600	S-C-L-W
Gulf Oil Corp	Sweetwater	6,400	S-C
Hammon Oil and Refining Co	Bay City	3,000	S
Humble Oil and Refining Co	Baytown	175,000	S-C-L-A
Humble Oil and Refining Co	Ingleside	30,000	S-C
Humble Oil and Refining Co	San Antonio	6,200	S
Independent Refining Co	Arp	3,500	S-C
Inland Refining Co	Tucker	2,000	S
Lacy, Roger, Refinery	Kilgore	2,500	S-C
La Salle Petroleum Corp	Burkburnett	2,500	S
Magnolia Petroleum Co	Beaumont	105,000	S-C-L-W
Magnolia Petroleum Co	Fort Worth	12,000	S-C
Maritime Oil Co	Houston	5,000	S
Master Petroleum Co	Dallas	1,500	S
McBride Refining Co., Inc	Edinburg	1,200	S
Minerva Refining Co	Minerva	1,250	S
Motor Fuels Corp	Levelland	4,000	S-C
Moutray Oil Co	Hawley	1,000	S-C
Nueces Refining Co	Clarkwood	2,500	S
Onyx Refining Corp	Abilene	2,000	S-C
Pan American Refining Corp	Texas City	97,000	S-C
Panhandle Refining Co	Lueders	1,500	S-C
Panhandle Refining Co	Wichita Falls	4,000	S-C
Patton Oil Co	Rotan	800	S
Payward Refining Co	Shamrock	700	S
Phillips Petroleum Co	Borger	39,000	S-C
Phoenix Oil and Refining Co	Pettus	1,000	S
Phoenix Refinery Co	Houston	2,500	S
Pioneer Oil and Refining Co	Somerset	1,400	S-L-A
Pontiac Refining Corp	Corpus Christi	10,500	S
Premier Oil Refining Co	Fort Worth	5,000	S-C-L-W
Premier Oil Refining Co. of Texas	Greggton	4,500	S-C
Prichard Refining Co., Ltd	San Antonio	3,000	S-C
Pure Oil Co	Nederland	48,700	S-C
Rado Refining Co	McAllen	1,000	S
Refugio Refinery Co., The	Refugio	1,000	S
Republic Oil Refining Co	Texas City	20,000	S-C
Shamrock Oil and Gas Corp	Sunray	3,000	S-C
Shell Oil Co., Inc	Houston	74,000	S-C
Shelly Refinery Co., Inc	Bay City	1,700	S-C
Sinclair Refining Co	Corpus Christi	12,000	S
Sinclair Refining Co	Fort Worth	6,200	S-C
Sinclair Refining Co	Houston	73,000	S-C-L-W
Skelly Oil Co	Longview	10,000	S-C
Southport Petroleum Co. of Delaware	Texas City	20,000	S-C
Southwestern Oil and Refining Co	Corpus Christi	14,000	S-L
Texas—Continued			
Standard Oil Co. of Texas, Inc	El Paso	14,000	S-C
Star Light Refining Co., Inc	Ballinger	600	S
Stone Oil Co	Texas City	7,500	S
Talco Asphalt and Refining Co	Mount Pleasant	10,000	S-C-A
Taylor Refining Co	Corpus Christi	22,500	S-C
Texas Co	Amarillo	7,500	S-C
Texas Co	Dallas	15,000	S-C
Texas Co	El Paso	2,500	S-C
Texas Co	Galena Park	27,500	S-C
Texas Co	Port Arthur	135,000	Comp.
Texas Co	Port Neches	40,000	S-A
Texas Co	San Antonio	6,000	S-C
Three Rivers Refinery	Three Rivers	1,500	S-L-A
Tydal Refinery Co	Gainsville	1,500	S
Waggoner, W. T., Estate	Electra	4,000	S-C
Western Refining Co	Fort Stockton	1,000	S
Wickett Refining Co	Wickett	4,000	S
Oklahoma			
Allied Material Corp	Stroud	1,500	S-L-A
Anderson-Prichard Refining Corp	Cyril	8,000	S-C-A
Bareco Oil Co	Barnsdall	5,000	S-C-L-W
Bell Oil and Gas Co	Granfield	5,000	S-C
Ben Franklin Refining Co	Ardmore	4,500	S-C-A
Champlin Refining Co	Enid	16,000	S-C-L-W
Cities Service Oil Co. (Del)	Ponca City	11,000	Comp.
Continental Oil Co	Ponca City	26,000	S-C-L-W
Cosco Oil Co	Wynnewood	3,000	S-C-A
Cushing Refining and Gasoline Co	Cushing	5,000	S-C
Deep Rock Oil Corp	Cushing	10,500	Comp.
Johnson Oil Refining Co	Cleveland	5,500	S-C
Mercury Oil Refining Co	Oklahoma City	2,000	S-C
Mid-Continent Petroleum Corp	West Tulsa	40,000	Comp.
Monarch Refineries, Inc	Oklahoma City	1,000	S-A
Peppers Gasoline Co	Oklahoma City	500	S
Phillips Petroleum Co	Okmulgee	7,000	S-C-L
Rock Island Refining Co	Beckett	7,500	S-C-A
Sinclair Refining Co	Sand Springs	4,500	S-C-L-W
Sunray Oil Co	Allen	8,750	S-C
Texas Co	West Tulsa	22,000	S-C-L
Tide Water Associated Oil Co	Drumright	12,000	S-C
Wilcox, H. F. Oil and Gas Co	Bristow	5,000	S-C
Louisiana			
Arkansas Fuel Oil Co	Bossier City	27,000	S-C
Atlas Oil and Refining Co	Shreveport	12,000	S-C
Bayou State Oil Corp	Houston	800	S-L-A
Chalmette Petroleum Corp	Chalmette	8,000	S-C
Clarke' Super Gas Co	Monroe	2,000	S
Continental Oil Co	West Lake	8,000	S-C
Evangeline Refining Co	Jennings	1,000	S-L
Evansville Oil Corp	Cotton Valley	2,500	S
General Oil Corp	Meraux	5,000	S
Pan American Petroleum Corp	Destrehan	7,500	S-A
Premier Oil Refining Co. of Texas	Cotton Valley	6,000	S
Princeton Refining Corp	Princeton	600	S-L-A
River Petroleum Corp	New Orleans	5,000	S-L
Shell Oil Co., Inc	Norco	21,000	S-C-A
Standard Oil Co. of Louisiana	Baton Rouge	120,000	Comp.
Stanolind Oil and Gas Co	Vivian	3,300	S-C

*Comp.—Complete plant, gasoline, kerosene, gas oil, fuel oil, lubricating oils, paraffin, wax, and asphalt, usually includes cracking.

S—Gasoline, kerosene distillate, gas oil, and fuel oil.

L—Lubricating oils.

A—Asphalt.

C—Same products as skimming, except plants are equipped for cracking.

W—Wax.

Season's Greetings

Another year of war for all, sorrow for many and toil for most of us, is about to end. But with it all, old friends and new friends are now, more than ever, symbols of America and what America stands for.

We want to extend Season's Greetings to our many friends—to thank them for their loyal support which we shall always do our utmost to preserve and deserve—and to wish for them a full measure of happiness and prosperity throughout the coming year —and for all the years ahead.

Sincerely,

John Grant

GRANT OIL TOOL CO.

2042 East Vernon Ave[illegible] Los [illegible]ng[illegible]11, California

Branches: Avenal • Bak[illegible]field • Santa Maria • Ventura

earnings were paid in the Gulf Coast area of Texas with $1.24 an hr., whereas lowest average earnings were found in the Inland Texas area where workers earned only $1.00 an hr. By way of comparison, refinery workers in the Louisiana Gulf Coast area received average wages of $1.22 an hr., in North Louisiana $1.06, and in Oklahoma $1.05 an hr.

In Texas, average earnings ranged from 79 cents per hr. for janitors to $1.38 for cracking stillmen and class A electricians (Table 6); in Oklahoma, earnings were lowest for watchmen at 78 cents per hr. and highest for working foremen in the processing departments with $1.39 (Table 4); the range of earnings in Louisiana was from 64 cents per hr. for janitors to $1.70 per hr. for working foremen (Table 5). Thus both the lowest and highest occupational average hourly earnings were found in Louisiana.

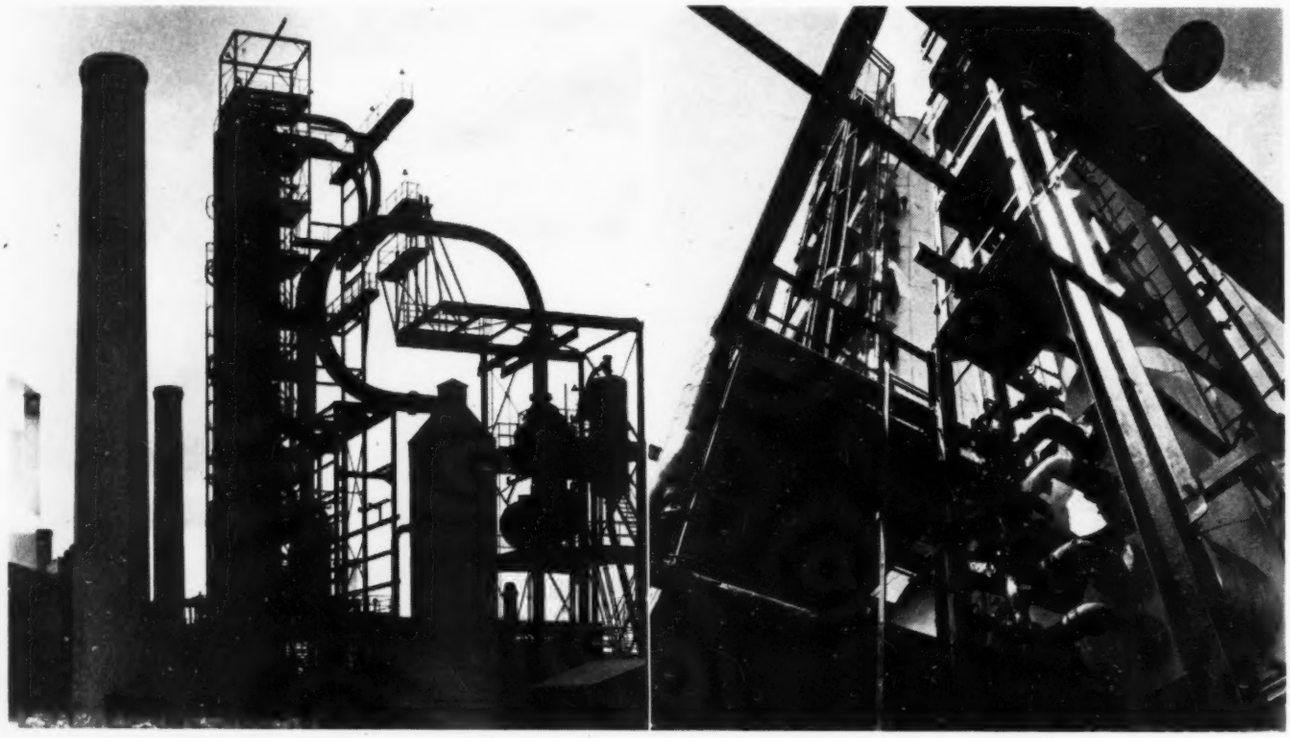
In Texas, 6 occupational classifications showed averages below $1 in contrast with Oklahoma where average hourly earnings were less than $1 in 13 cases, and in Louisiana where only 4 classifications received less than $1 per hr. In Texas, 13 occupational classifications received $1.25 or more per hr.; in Louisiana, 9 received more than this amount; and in Oklahoma, only 2 occupational classifications were paid more than $1.25 per hr. In general, this is indicative of the wage levels of the respective areas.

To a considerable extent, these differences reflect regional differences in the characteristics of the industry rather than geographical variations in general wage levels. Differences in size of plant and in technological processes are important in this respect.

Of the 22 occupational groups analyzed in Table 7, average earnings in the smallest plants are well below those in both groups of larger operations for 21 occupations; the single exception involves the 7 packers. In the comparison between the plants with 51 to 250 employees and those with more than 251 workers, the same type of relationship is apparent. For each of the 34 occupational groups, average earnings in the middle-sized plants are below those for the largest operations. The differences in some cases are, as might be expected, less pronounced than those resulting from a comparison of the largest and smallest plants.

Wide differences also appear in the comparison of earnings in refineries with cracking units and those operating with simpler processes. With the single exception of class B machinists, average earnings in the cracking plants are significantly above those for the other operations in the 26 occupational groups for which data are shown in Table 8. It is thus apparent that the predominance of large refinery units and/or cracking processes within an area would consequently result in higher wage levels than those found in an area where such influences were less in evidence. For example, the location of large plants equipped for cracking in the Gulf Coast areas of Louisiana and Texas are principally responsible for higher wage rates here than in the inland areas of these States.

Local labor market conditions and unionization have also contributed to area wage differentials. Union plants in general pay higher wages than nonunion. Consequently, the degree of plant unionization within an area would influence the level of wages. It is exceedingly difficult to estimate the influence of local labor market conditions. Critical manpower shortages in certain areas have doubtless influenced wage rates, but, on the other hand, the wage stabilization program has presumably operated to counteract such an influence. From evidence available in Bureau of Labor Statistics files, it appears that area wage differentials in petroleum refining are primarily the result of size of establishment and processing technique utilized and only secondarily the result of differences in unionization, local labor conditions, and other industrial characteristics.



At the close of 1942, 31 percent of the refineries in the United States were situated in the Southwest—Texas, Oklahoma, and Louisiana—with a capacity of 39 percent of the nation's refining capacity

☆ ☆ WAGNER PRODUCTS SPEED VICTORY ☆ ☆

Wagner

These motors are especially designed to resist the damaging action of acids, fumes, moisture, and other destructive elements. They are ideal for chemical manufacturing plants, as well as in industrial plants where operating conditions are adverse to the use of open-type motors.

Features of Construction

Wagner Type CP Chemical Motors have windings which are well insulated and impregnated, and coils and free-ends of stator windings are shaped to fit snugly into special slot cells.

After windings are in place, the stator is baked to remove all moisture, and while still hot it is immersed in a heavy insulating varnish. When this coating is completely dried, the stator is then given another dipping and baking to insure complete impregnation. Finally, it is treated with a heavy coat of a special alkali- and acid-resisting varnish, which produces a tough oil-proof coating.

The conduit box is moisture-proof and dust-tight, and is screwed onto a nipple solidly welded into the side of the motor. The cover of the conduit box is firmly held by four bolts.

All lead openings are completely sealed with a flexible compound, preventing the entrance of dust, fumes, moisture and other harmful elements.

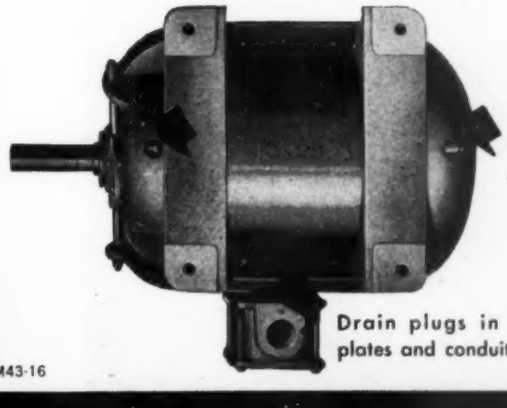
Special drain plugs in the bottom of the endplates and conduit box provide for the removal of any condensation from the motor or conduit box.

The inner frame completely seals the windings and bearings while the outer frame guides a cooling draft over the motor.

Other features include: dynamic balance (running balance) which insures freedom from vibration; and completely sealed ball bearings.

Conduit box—screw-on type.

Completely sealed leads.



Drain plugs in endplates and conduit box.

M43-16

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Wagner Electric Corporation

ELECTRICAL AND AUTOMOTIVE PRODUCTS

Effect Savings

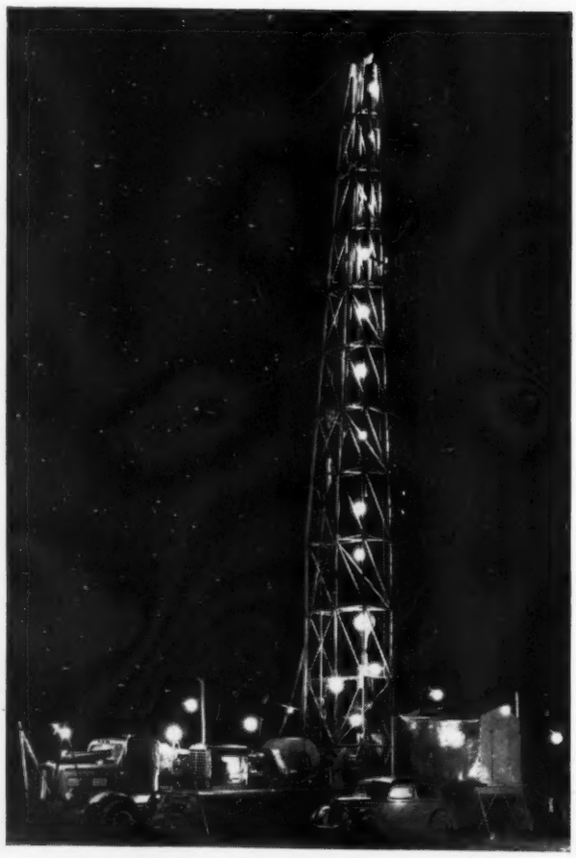
Since Franks revolutionized the producing division of the oil industry with its "Slim-hole" 100% portable drilling rig and 100% portable telescoping derrick servicing unit, the trend has been toward greater economy in drilling and servicing operations.

Many have tried to copy Franks equipment, but Franks has stayed ahead of the parade with constant improvements.

Franks portable rotary drilling rigs are complete with derrick, crown block, stacking board, swivel, kelly, rotary table, drawworks, pumps and power plant, all unitized on a single truck. The derrick folds down over the truck for moving. Blocks and lines remain strung in moving.

Franks rigs eliminate the cost of permanent derricks, save considerably in rig-up, tear-down and moving time, save in water, fuel and labor, since they are designed for a three man crew.

Investigate Franks rigs before you buy.



Franks Truck-Mounted Portable Rotary Drilling Rig with a 96 ft. derrick as an integral part operating at night. The derrick folds down over the truck for moving. This rig is capable of drilling to 6,000 ft.

THE *Petroleum* Engineer's CONTINUOUS TABLES

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INSTALLMENT NO. 78

A VALUABLE and regular feature of *The Petroleum Engineer,* the Continuous Tables, now in their seventh year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer.* Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously. More than 450 tables have been published.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

To readers of *The Petroleum Engineer,* who are only now becoming interested in the Continuous Tables, it should be pointed out that each table is assigned a filing or index number that conforms with the Dewey Decimal System of classification as modified and extended for the petroleum and related industries by L. C. Uren, professor of Petroleum Engineering at the University of California. This complete index has been published in earlier installments of the tables and is now available in booklet form at a cost of 50 cents per copy from *The Petroleum Engineer,* P. O. Box 1589, Dallas, Texas. Complete sets of the tables from the first installment to the present are also available in conjunction with subscriptions at the rate of $3.00 a year, or $4.00 for two years. General field classification numbers are as follows:

Nos. P000-P399—General

Nos. P400-P-499—Drilling

Nos. P500-P599—Production

Nos. P600-P699—Transportation and storage (includes pipe line)

Nos. P700-P799—Refining, including

Nos. P770-P799—Natural Gasoline, which may be classified in a separate division as shown here if of special interest to the user

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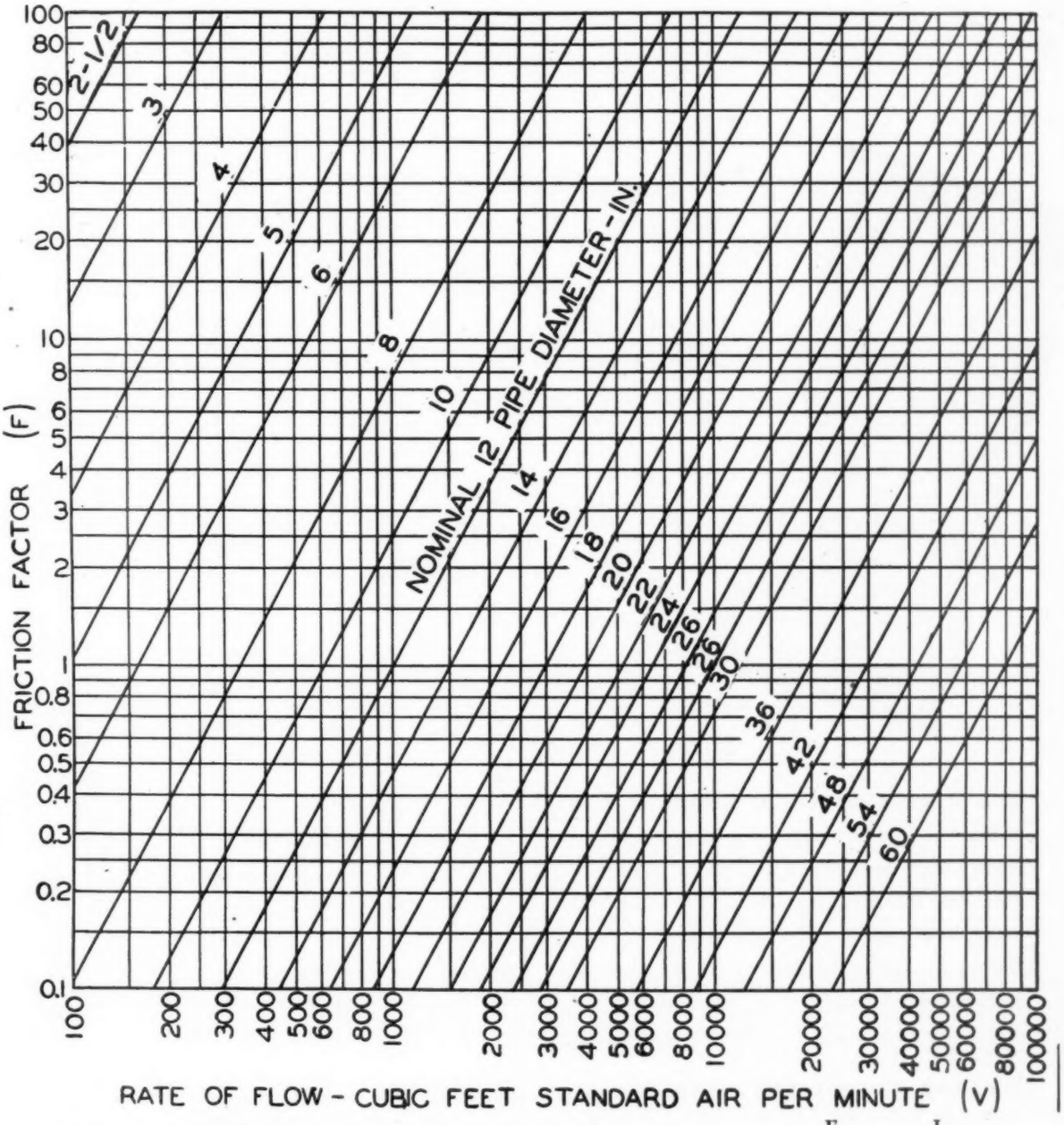
FRICTION OF AIR IN PIPES

Chart based on Formula: $D = \frac{0.7V^{1.85}}{d^5 P_m} \times \frac{L}{1000}$

Where:

D = pressure drop, lb. per sq. in.,
V = cu. ft. of air flowing through pipe measured at 14.7 lb. per sq. in. abs. and 60°F.,
L = length of pipe, ft.,
d = internal diameter of pipe, in., and
P_m = mean pressure in pipe, lb. per sq. in. abs. P_1 = initial pressure and P_2 = final.
F = friction factor from chart = $\frac{0.7V^{1.85}}{d^5}$.



Find F from chart and substitute in formula D = pressure drop in lb. per sq. in. = $\frac{F}{P_m} \times \frac{L}{1000}$

Where:

L = length of pipe, ft., and
P_m = mean pressure in pipe, lb. per sq. in.

$$P_m = P_1 - \frac{D}{2} = P_2 + \frac{D}{2}$$

Use of P_1 or P_2 gives approx. results.
P_m must be obtained by trial.

—Chart courtesy Compressed Air Data.

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One of these invariably justifies its specification

1 LASTING LONGER
2 BEING SAFER TO HANDLE
3 SPOOLING BETTER
4 BEING FASTER TO INSTALL
5 REQUIRING NO SEIZING
6 REFUSING TO "PORCUPINE"
7 MAKING LANG-LAY MORE SERVICEABLE
8 BEING FREE OF TENDENCIES TO KINK
9 RESISTING BENDING FATIGUE LONGER
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The absence of internal stresses in Hazard **LAY-SET** Preformed wire rope makes it unnecessary to seize the rope with serving wire before cutting. Every wire and every strand is "at ease," comfortable in its assigned position, not at straining odds with every other wire and strand as is the case with non-preformed rope. Here is proof positive that **LAY-SET** is easier, faster, and safer to handle; that being free of torsional strain it will work better, last longer, give greater dollar value. Specify Hazard **LAY-SET** Preformed for *all* its built-in advantages.

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HAZARD LAY-SET *Preformed* ROTARY LINES

PHYSICAL CONSTANTS OF HYDROCARBONS

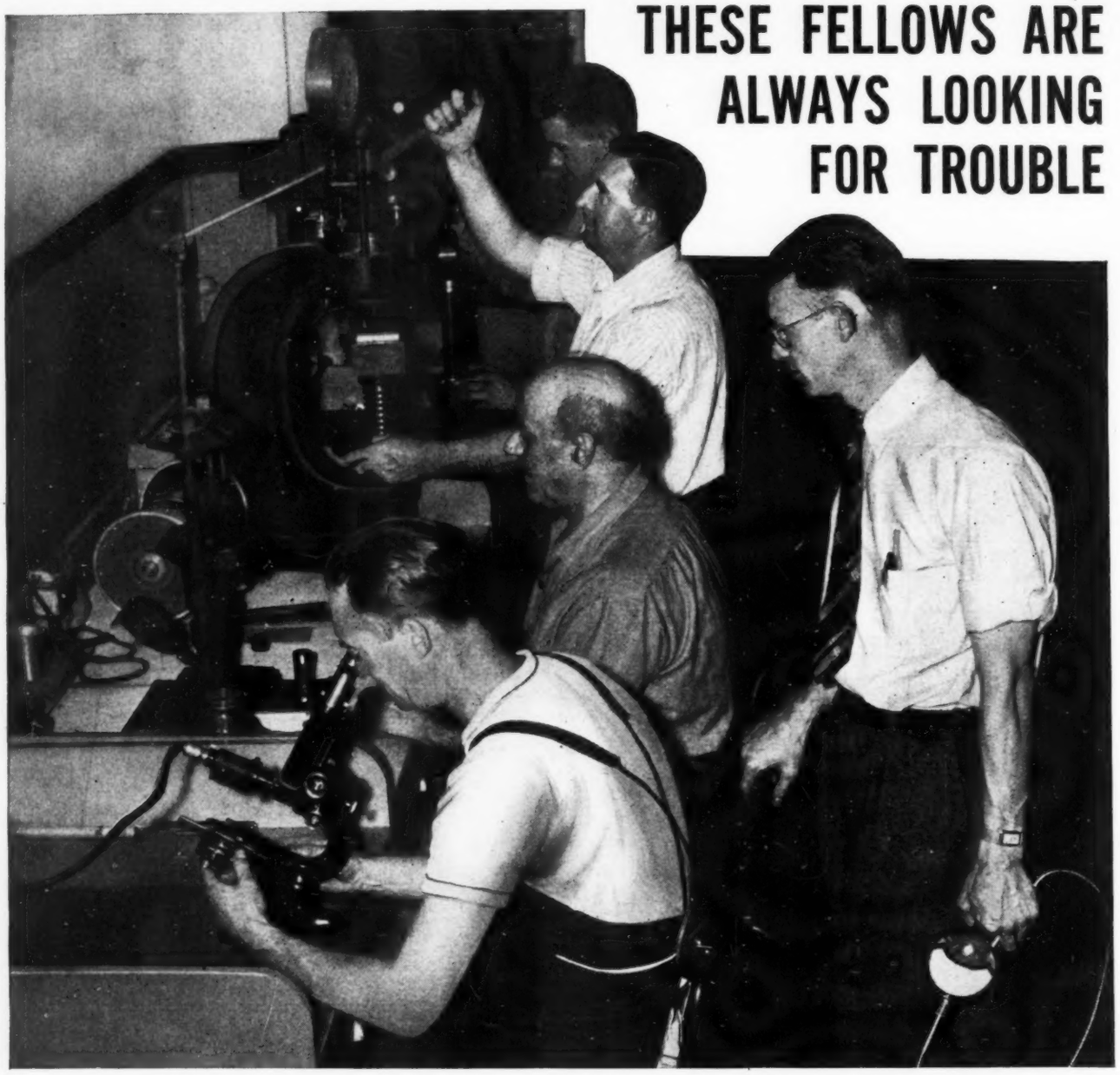
Hydrocarbon	Specific gravity 20/4 °C.	M. P.	B. P.	Index of refraction n_D^{20}	Viscosity Abs. Poises	Specific heat	Heat of vaporization Cal/G.	Heat of combustion K-Cal/mol	Aniline point °C.	Coeff. of expansion °C.	Critical constants P Atm.	Critical constants T °C.	Critical constants D	Vapor pressure °C.	Vapor pressure mm.	Octane number Actual	Octane number Blending	Surface tension Flash °C.
3-Methylhexane	0.6870	—119.4	91.96	1.3887	0.0037^{20}	$0.511^{16.2}$	76.6	1150.2p	70.6 cst	0.001228	28.1	262.4	..	18 51 85	50 200 600	65r	65r	19.56 ....
2, 2, 3-Trimethylbutane (Triptane)	air 3.459 0.6900	—25.06	80.87	1.3895	0.0080^{0} 0.0059^{20}	$0.497^{20.9}$	74.7	1147.97	72.2 cst	0.001215	29.7	258.3	..	33.90 51.12 68.81	149.4 289.1 525.8	1.83r* 0.07m*	112.5r 112.5m	18.68 ....
3-Ethylpentane	0.69818	—118.6	93.473	1.39337	0.00377	$0.519^{21.8}$	77.2	1150.6p	65.7	0.001222	28.6	267.6	..	46.40 63.68 81.40	149.4 289.1 525.8	62r	68r	20.16 ....
C_8H_{18} Octane	air 3.940 0.7028	—56.8	125.6	1.3976	0.0070^{15} 0.0053^{920}	0.526^{25}	71.0	1306.8p	72.1 cst	0.00116^{0-30}	25.2	295.9	0.232	90 120	263.5 646.4	—17m	—19r	21.71 13.34
2-Methylheptane (Isooctane)	0.6976	—111.3	118.1	1.3955	0.0057^{710} 0.0051^{820}	....	68.2	1306.1p	74.0 cst	.....	..	285.5	..	.....		21.7r 23.8m	....	20.91 ....
3-Methyheptane	0.70584	—120.9	119.05	1.3985	0.0057^{010} 0.0050^{820}	....	68.5	1298.4	72.2 cst	.....	..	289.4	..	.....		26.8r 35.0m	....	21.29 ....
4-Methylheptane	0.7042	—121.3	117.5	1.3980	0.0053^{310} 0.0047^{720}	....	70.86	1298.4	71.6 cst	.....	..	293.3	..	.....		26.7r 39.0m	30.5r 47.5m	....
3-Ethylhexane	0.7128	Glass	118.7	1.4021	0.0051^{310} 0.0045^{720}	....	68.2	1303.3p	68.7 cst	.....	..	292.0	..	.....		33.5r 52.4m	....	....
2,5-Dimethylhexane (Diisobutyl)	air 3.944 0.6939	—90.1	109.25	1.3928	0.0051^{215} 0.0043^{230}	....	68.12^{100}	1303.5p	78.0 cst	0.00119^{0-30}	24.5	276.8	0.2366	80 100	305.5 578.8	55.5r 55.7m	69.0r	19.80 ....
2, 2, 3-Trimethylpentane	0.71617	—112.3	109.84	1.40285	0.0068^{1510} 0.0061^{9020}	....	68.0	1298.4	70.8 cst	0.001118	..	285.0	..	.....		1.18r* 99.9m	104.5r 111.5m	20.80 ....
2, 2, 4-Trimethylpentane ("Isooctane")	air 3.944 0.69196	—107.3	99.233	1.3914	0.0050^{2520} 0.0035^{950}	$0.489^{22.2}$	68.3	1303.4p	80.4 cst	.....	25.4	271.1	..	25.26 58.10 85.09	50 200 500	100r 100m	100r 100m	18.85 —9.0
2, 3, 3-Trimethylpentane	0.7258	....	114.6	1.4072	.....	....	69.0	1302.5	67.0 cst	.....	..	290.2	..	.....		0.61r* 99.4m	100.0r 109.5m	....
2, 3, 4-Trimethylpentane	0.71903	—109.4	113.39	1.4043	0.0056^{0010} 0.0050^{2020}	$0.515^{21.7}$	68.5	1302.5	68.3 cst	.....	..	287.5	..	.....		0.22r* 95.9m	97.0r 102.0m	....
2, 2, 3, 3-Tetramethylbutane (Hexamethylethane)	0.7219†	+101.6	106.5 106.6	1.408	0.0069^{8510} 0.0063^{4020}	$0.486^{22.2}$	68.1	1301.3p	None	.....	24.5	270.8	0.2366	—10.3 6.0	1.33 5.80	103m	130r	....

See table P 771.001.B for footnotes.

*cc. lead in *isooctane*.
†Extrapolated, liquid.

Table from "Physical Constants of the Principal Hydrocarbons," 4th edition, by courtesy of copyright owner, The Texas Company.

THESE FELLOWS ARE ALWAYS LOOKING FOR TROUBLE



—so they can prevent it! They're the "watch dogs" of our Heat Treating Processes, where good bearings get off to a good start. Theirs is a roving commission, *re*-checking the checking done by the regular inspectors—to make doubly sure each step of the Heat Treatment of Hyatt Roller Bearings produces perfect results.

'Round the clock, 'round the year, they're on the job, looking for trouble—to save *you* trouble. They've worked out a series of continuing tests covering every phase of Heat Treatment. Some are repeated every 15 minutes, others several times an hour—some take only several seconds, others several hours. All are important...as is every test in precision bearing manufacture.

So important, in fact, that one out of every 6 Hyatt employes devotes his time to testing and inspection in various stages of manufacture.

Sound like a lot of work? It is—but worth it when you remember that more than 90% of all Hyatt Roller Bearings made today go directly into fighting equipment or the machinery that helps build it.

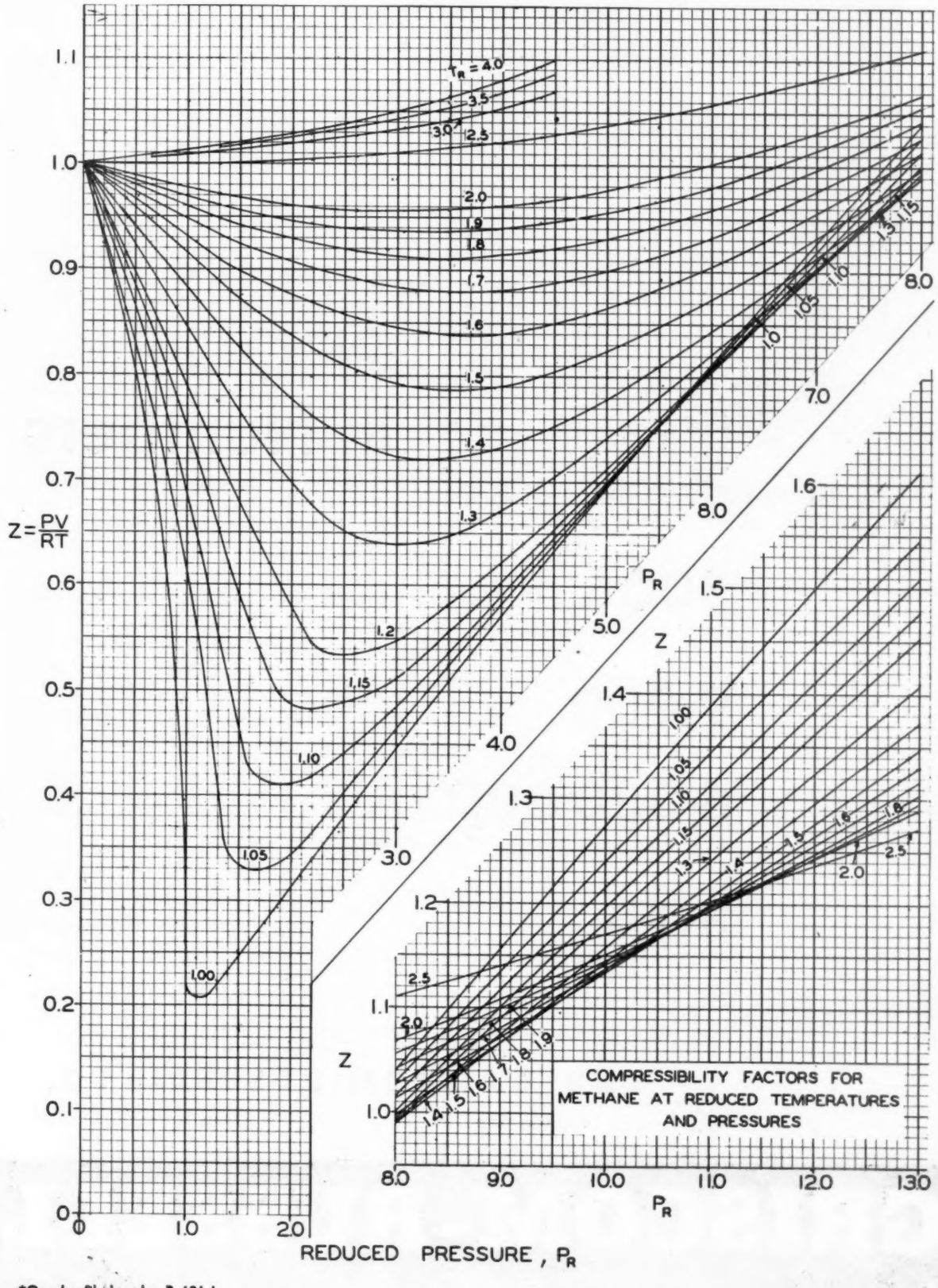
That's why we've *got* to make 'em good. Because Victory is our Business.

Hyatt Bearings Division of GENERAL MOTORS CORPORATION, Harrison, N. J.

Pave the Road to Victory with War Bonds

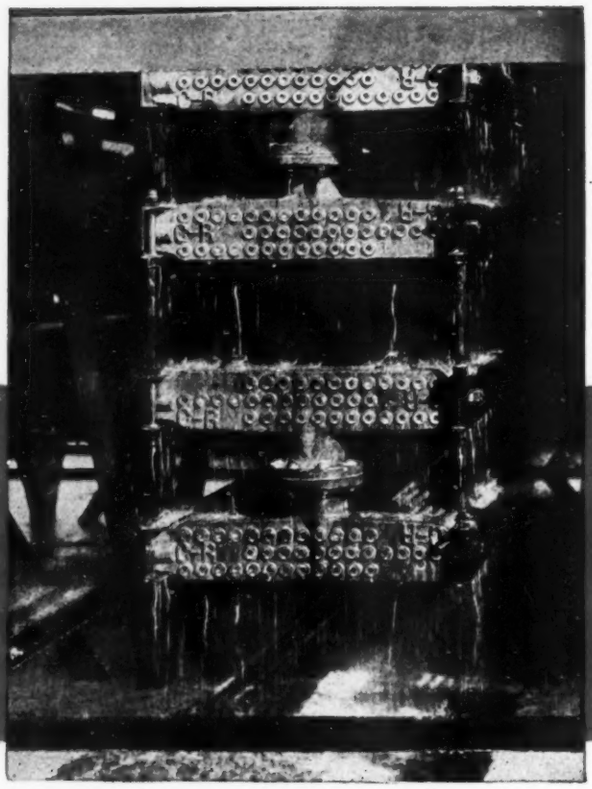
HYATT BEARINGS DIVISION OF GENERAL MOTORS

Compressibility Factors for Methane at Reduced Temperatures and Pressures



*Can be filed under P 621.1

—*Chart by George Granger Brown, University of Michigan.*



The Griscom-Russell Co. has recently received its fourth award for excellence in production

There's PROOF in Numbers

G-R Bentube Sections in operation under cooling tower, showing even distribution of water

300 • • • the number of refineries and natural gas companies that use G-R Bentube Sections.

9,000 • • • the number of G-R Bentube Sections in service.

6,000,000 • • • the number of gallons of gasoline being daily condensed or cooled by G-R Bentube Sections.

80% • • • the proportion of natural gas used in the United States which is handled in pipe line compressor stations equipped with G-R Bentube Sections.

Write for bulletin describing G-R BENTUBE SECTIONS in detail

THE GRISCOM-RUSSELL CO.

285 Madison Ave. New York 17, N. Y.

GRISCOM-RUSSELL

Pioneers in Heat Transfer Apparatus

PHYSICAL CONSTANTS OF HYDROCARBONS

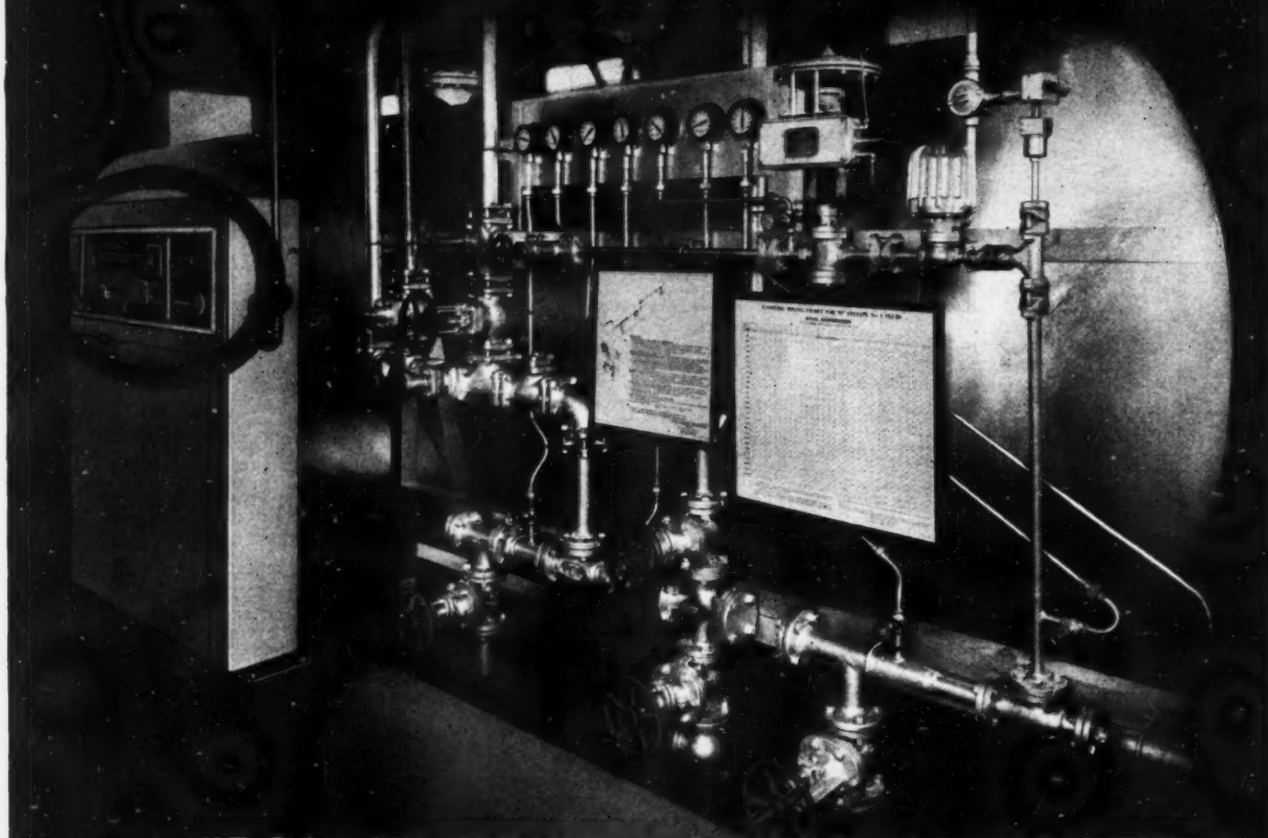
Hydrocarbon	Specific gravity 20/4 °C.	M. P.	B. P.	Index of refraction n_D^{20}	Viscosity Abs. Poises	Specific heat	Heat of vaporization Cal/G.	Heat of combustion K-Cal/mol	Aniline point °C.	Coeff. of expansion °C.	Critical constants P Atm.	Critical constants T °C.	Critical constants D	Vapor pressure °C.	Vapor pressure mm.	Octane number Actual	Octane number Blending	Surface tension Flash °C.
C_5H_{12} Pentane	$\frac{2.491^{air}}{0.62624}$	—129.7	36.0	1.3576	0.002830 0.0023220	$0.557^{16.9}$	85.5	845.27p	71.7^{cst}	0.00154^{0-30}	33.0	197.2	0.232	—25 2 30	50 200 600	61.7r 61.9m	61.5r 66.5m	$\frac{15.98}{49.0}$
2-Methylbutane (Isopentane)	$\frac{2.491^{air}}{0.61972}$	—160.6	27.89	1.3539	0.002740 0.0023415	$0.562^{16.9}$	83.3	843.36p	78.9^{cst}	0.001546^{5-10}	32.9	187.8	0.234	—33 — 5 22	50 200 600	92.3r 90.3m	99.5r 103.5m	$\frac{14.97}{-55.5}$
2, 2-Dimethyl-propane (Neopentane)	$\frac{2.491^{air}}{0.5904}$	—16.8	9.45	1.34725	.....	$0.543^{5.7}$	76.2	840.61p	102.0	.....	33.0	184.0	..	—13.83 — 1.58 14.10	300 500 900	85m	116r	....
C_6H_{14} Hexane	$\frac{2.975^{air}}{0.65943}$	—95.39	68.75	1.3750	0.00331515 0.0027830	$0.356^{22.0}$	79.4	1002.4p	69.1^{cst}	0.00135^{0-30}	29.5	234.8	0.234	30 50	186.1 400.6	24.8r 26.0m	29r	$\frac{18.41}{-18.0}$
2-Methylpentane (Isohexane)	$\frac{2.975^{air}}{0.65316}$	—154.0	60.30	1.37151	0.003711020 0.003120	$0.552^{26.9}$	76.5^{60}	998.54	73.9^{cst}	0.001476^{20-30}	..	228.0	..	30 54	250 600	73m	69r 73m	$\frac{17.31}{....}$
3-Methylpentane	$\frac{2.975^{air}}{0.66435}$	—118.0	63.23	1.3766	0.00394020 0.003391515 0.003072525	$0.521^{26.9}$	77.5	993.3	69.3^{cst}	.....	31.9	227.0	..	— 2 26 55	50 200 600	75m	85.5r 80.5m	$\frac{18.10}{....}$
2,2-Dimethylbutane (Neohexane)	$\frac{2.975^{air}}{0.64919}$	—100.0	49.731	1.3688	0.00477020 0.003971515 0.003752020	$0.511^{26.9}$	$73.8^{149.6}$	989.9	81.2^{cst}	.....	30.0	216.9	..	0 25	100 300	91.8r 93.4m	97.8r 93.4m	$\frac{16.18}{-47.2}$
C_7H_{16} Heptane	$\frac{3.459^{air}}{0.68378}$	—90.6	98.42	1.3877	0.005190 0.004102020	$0.525^{18.2}$	76.1	1150.77	70.6	0.001222	27.0	267.0	0.241	26.80 56.70 84.78	50 200 500	0r 0m	0r 0m	$\frac{20.26}{-2.0}$
2-Methylhexane (Isoheptane)	$\frac{3.459^{air}}{0.67869}$	—118.2	90.10	1.38490	0.004760 0.003812020	$0.523^{19.4}$	74.9	1149.5p	73.6^{cst}	0.001259	27.2	257.9	..	51.1 71.1	200 400	45m	55r	$\frac{19.17}{....}$

Nomenclature: Numbers are used in preference to Greek letters to indicate position of side chains. In the paraffins numbering begins in the longest chain at the terminal carbon nearest the side chain.

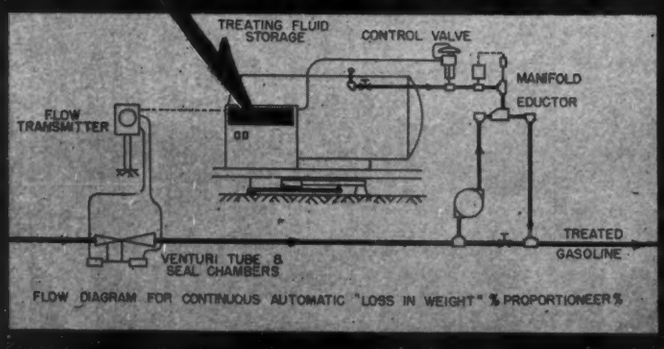
1. **Specific gravity:** Hydrocarbon at 20°C., compared to water at 4°C. unless otherwise indicated in superscript. For lighter hydrocarbons, gas density given is compared to air (usually 15°C.).
2. **Melting point:** Under atmospheric pressure, except in a few cases where slight pressure was used to prevent sublimation.
3. **Boiling point:** Under 760 mm. Hg, unless otherwise indicated in superscript.
4. **Index of refraction:** Sodium D-line at 20°C., unless otherwise indicated in superscript. Superscript (g) indicates gaseous state.
5. **Viscosity, absolute:** In poises at temperatures indicated in superscript (g) indicates gaseous state. Stokes indicated by s; in a few cases Engler degrees and Saybolt have been converted to stokes.
6. **Specific heat:** Ratio of thermal capacity of hydrocarbon to that of water at indicated temperature; hydrocarbon in liquid state except in case of the lower hydrocarbons where it was determined as a gas (g), or as a solid (s) in the case of very high melting point compounds; temperature where known is shown in superscript.
7. **Heat of vaporization:** Quantity of heat necessary to change one gram of liquid to vapor without change of temperature, atmospheric pressure; given in calories per gram (at b.p., unless otherwise indicated in superscript), which can be converted to B.t.u. per lb. by multiplying by 1.8.
8. **Heat of combustion (gross):** In kilogram calories per gram molecular weight of the hydrocarbon, in most cases under constant pressure (p) but in some cases under constant volume (v). Values are for liquid hydrocarbons unless designated by (g). To convert to B.t.u. per lb. divide the value considered as thousands (e.g. 712.8 equals 712,800) by the molecular weight and multiply the result by 1.8.
9. **Aniline point:** Lowest temperature (°C.) at which volumes of hydrocarbon and aniline become completely miscible. Where critical solution temperatures are given, the letters "cst" are shown. In some cases, however, the two terms and values are used indiscriminately.
10. **Coefficient of cubical expansion:** Ratio of the change in volume per °C. temperature change; the temperature range, where known is shown in superscript.
11. **Critical pressure:** Pressure given in atmospheres, under which a substance may exist as a gas in equilibrium with the liquid at the critical temperature.
12. **Critical temperature:** That temperature above which a gas cannot be liquefied by pressure alone.
13. **Critical density:** Volume of unit mass of substance at the critical temperature is termed the critical volume, and the reciprocal of this is the critical density.
14. **Vapor pressure:** In mm. Hg for temperatures shown.
15. **Octane numbers:** Given in both unblended and blended state; the C.F.R. research (r) or motor (m) method is specified. Blending octane: Definite amount of hydrocarbon being tested (usually 20 percent) is added to a base fuel of, say 60 O.N. If blend shows 70 O.N., that is, an increase of 10 O.N. for a 20 percent blend, then 100 percent would be 5 × 10 equals 50. Add 50 to 60 of base equals 110 blending value. Blending values are not directly comparable unless same amount of hydrocarbon and a base of the same octane number and same characteristics were employed.
16. **Surface tension:** In dynes per centimeter against air, at 20°C. unless otherwise indicated in superscript.
17. **Flash point:** In practically all cases, the apparatus used was not mentioned in the literature, but where known, O.C. and C.C. indicate open and closed cup, respectively.

—Table from "Physical Constants of the Principal Hydrocarbons," 4th edition, by courtesy of the copyright owner, The Texas Company.

FOR "PRODUCTION LINE" BLENDING



"LOSS IN WEIGHT" %PROPORTIONEER%



FLOW DIAGRAM FOR CONTINUOUS AUTOMATIC "LOSS IN WEIGHT" % PROPORTIONEER %

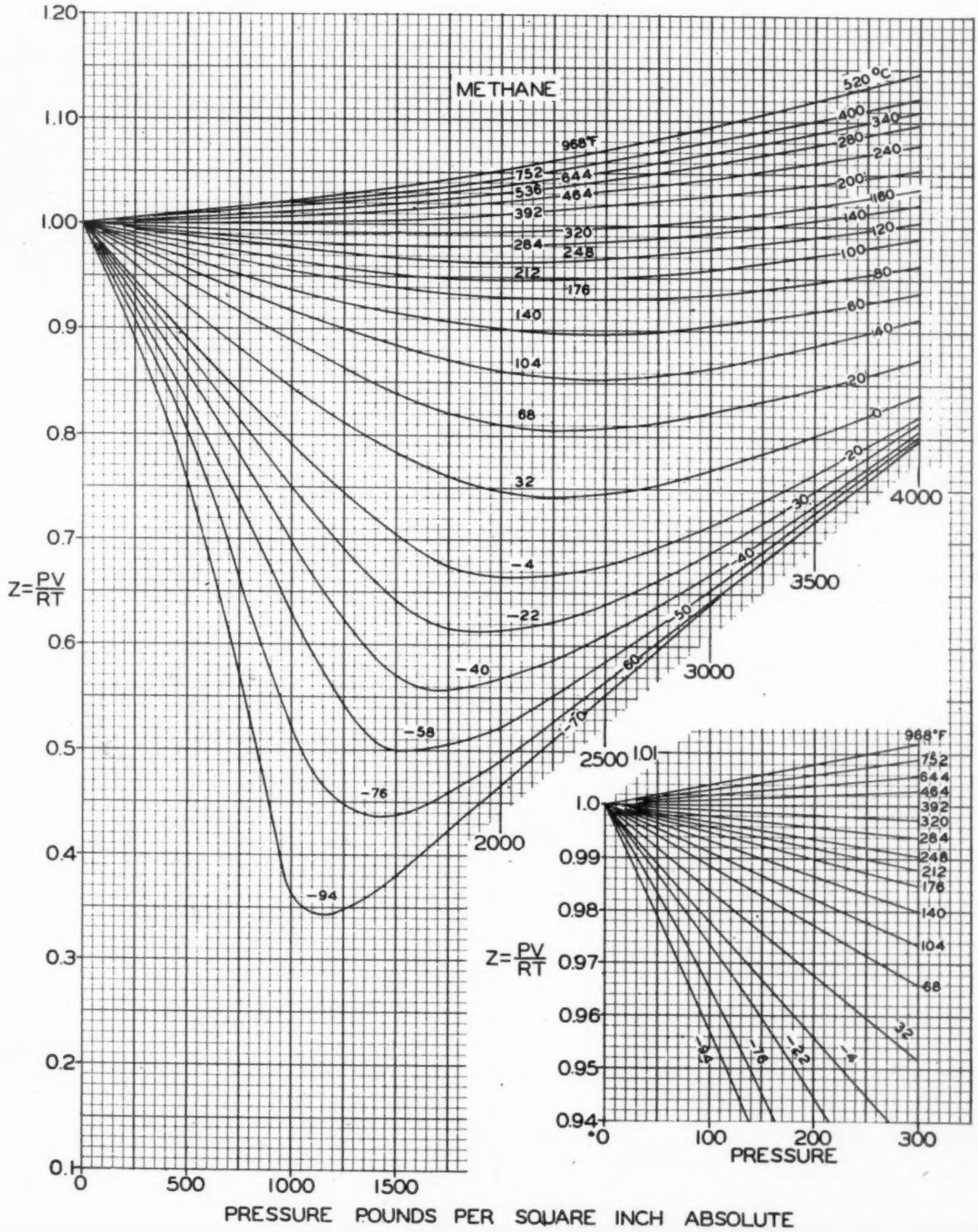
The "Loss in Weight" %Proportioneer% guarantees absolute accuracy and dependability in "flow responsive" addition of tetra ethyl lead for octane adjustment of gasoline.

Look to %Proportioneers, Inc.%, leaders in the field of proportioning equipment, for engineering advice on the transition from *Batch* to *Continuous* or "Production Line" methods. For recommendations on your particular requirements send complete job conditions.

% PROPORTIONEERS, INC. %

WRITE TO %PROPORTIONEERS, INC.%, 28 CODDING STREET, PROVIDENCE 1, RHODE ISLAND

Compressibility Factors for Methane at Absolute Pressures and Temperatures

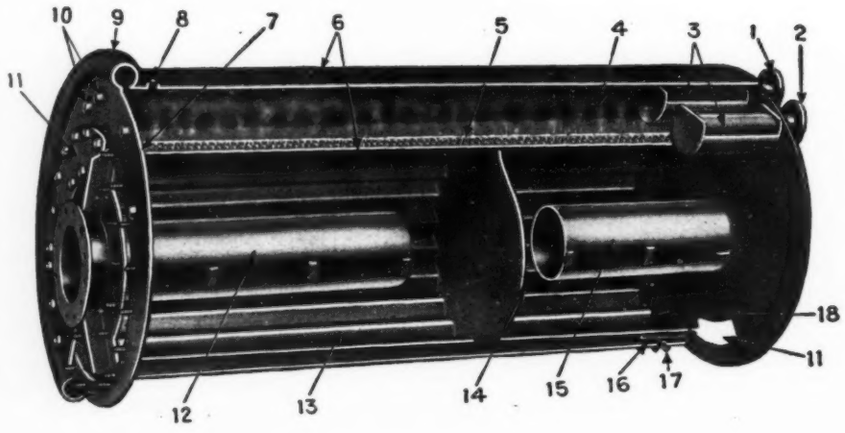


*Can be filed under P 621.2

—Chart by George Granger Brown, University of Michigan.

MAXIM HEAT RECOVERY SILENCERS *save fuel!*

Extra steam or hot water for industrial processing operations or for heating purposes can be readily obtained by utilizing waste exhaust heat with Maxim Heat Recovery Silencers. The fuel saving is obvious, as the heat source is simply the engine exhaust gases which normally are wasted.



1—Steam Outlet
2—Safety Valve Connection
3—Dry Pipes
4—Steam Space
5—Water Line
6—Shells—Cylindrical to withstand steam pressure and pulsating gas flow
7—Inlet Head
8—Pressure Gauge Connection
9—Expansion Joint—permits dry operation
10—Water Gauge Connections
11—Cleanouts—provide easy access for cleaning heating surface
12—Inlet Bleeder Tube
13—Extended Heating Surface—forming conduits for leading exhaust gases from one attenuating chamber to the other
14—Insulated Intermediate Head
15—Outlet Bleeder Tube
16—Feed Water Deflector Plate
17—Feed Water Connection
18—Exhaust Gas Outlet from side conduits formed by extended heating surfaces

HIGH HEAT RECOVERY... Maxim Heat Recovery Silencers achieve highly efficient heat transfer through high mass gas velocities and the use of extended heating surfaces, a type of construction that is extremely dependable and requires minimum attention.

HIGH DEGREE OF SILENCING... These units embody the Maxim principle of silencing and can be had with or without the spark arresting feature. Based on silencing principles pioneered by Maxim and developed through years of practical field experience, they afford highly effective silencing of exhaust with minimum of back pressure.

COMPACTNESS AND LIGHT WEIGHT... Maxim Heat Recovery Silencers are extremely compact and can in most cases be installed in the space normally used for a regular silencer unit.

AUTOMATIC CONTROL... In the boiler, the steaming rate is controlled by varying the amount of water in contact with the heating surface; low water, less effective heating surface; high level, more effective. The control is accomplished automatically by two steam pressure regulated valves, one in the feed line, one in the return line, working in conjunction. (See bulletin WH-100)

ABILITY TO RUN DRY... Because of the type of construction, with extended heating surfaces, not tubes, it is possible to run these units dry without any danger of damage.

QUICK RETURN ON INVESTMENT... Maxim Heat Recovery Silencers produce usable steam or hot water from a present source of heat. Hence steam or hot water for processing operations or for heating the plant is available with no extra fuel cost. This obvious saving represents a quick and often substantial return on your investment

AVAILABILITY... At this time the Maxim Silencer Company's production is devoted to war needs. It is our feeling, however, that this Waste Heat story has sufficient post-war importance to make your investigation worthwhile now, whether or not your present priority status allows immediate purchase of the equipment.

This northern Minnesota power plant is heated entirely through use of Maxim Heat Recovery Silencers.

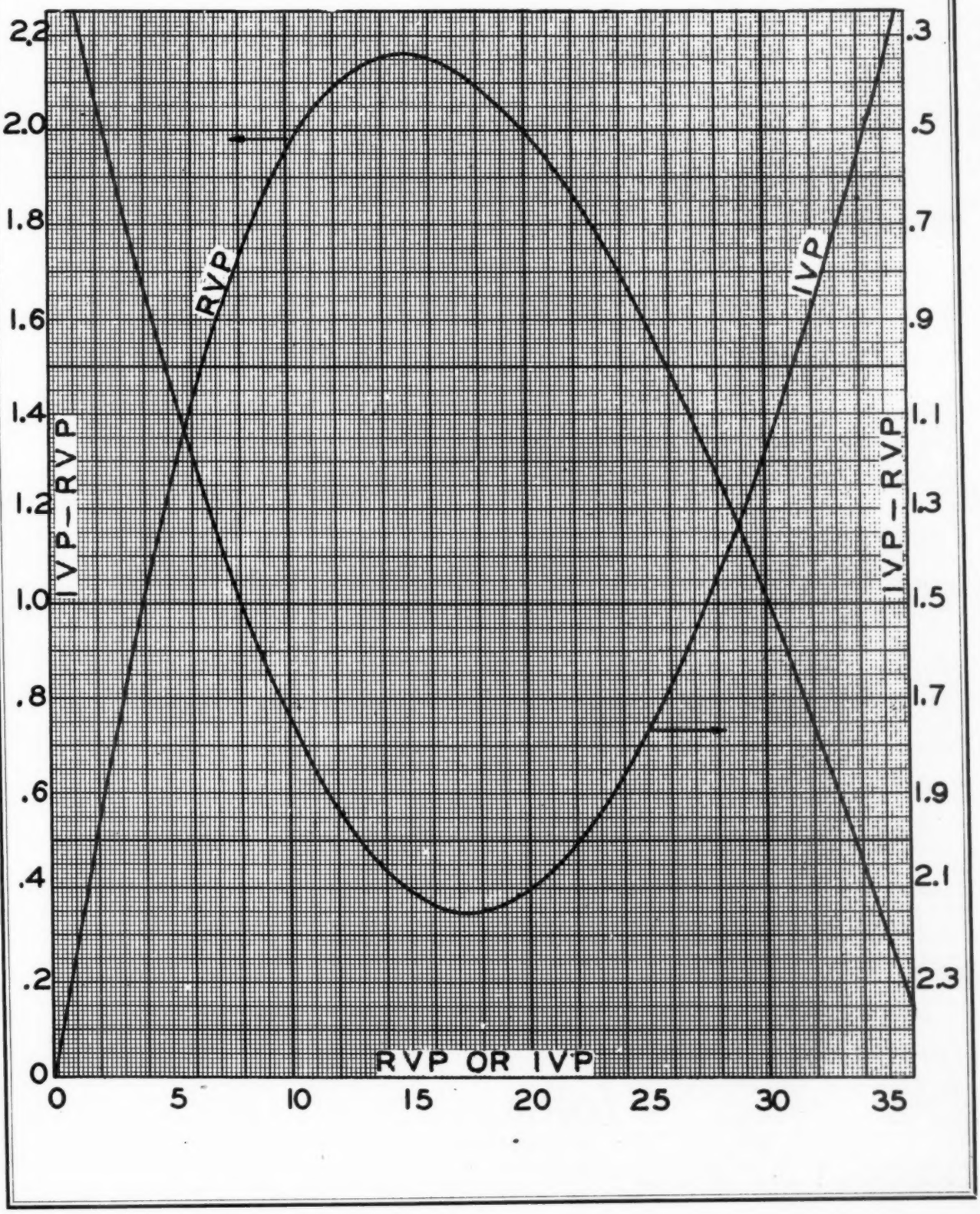
SEND FOR DESCRIPTIVE BULLETINS

Maxim Waste Heat Bulletins WH-100, WH-102 and WH-103 will be sent to you on request. Simply send your request to The Maxim Silencer Company at the address below.

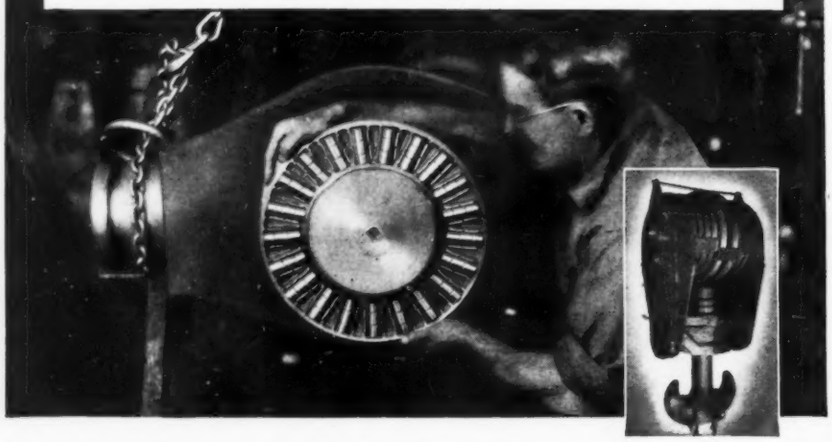
THE MAXIM SILENCER CO.
90 Homestead Ave., Hartford, Conn.

MAXIM

REID VAPOR PRESSURE VERSUS INITIAL VAPOR PRESSURE

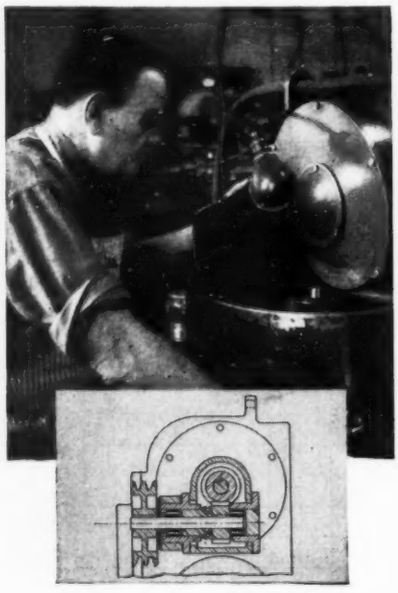


IN THE NEWS
WITH TORRINGTON–BANTAM

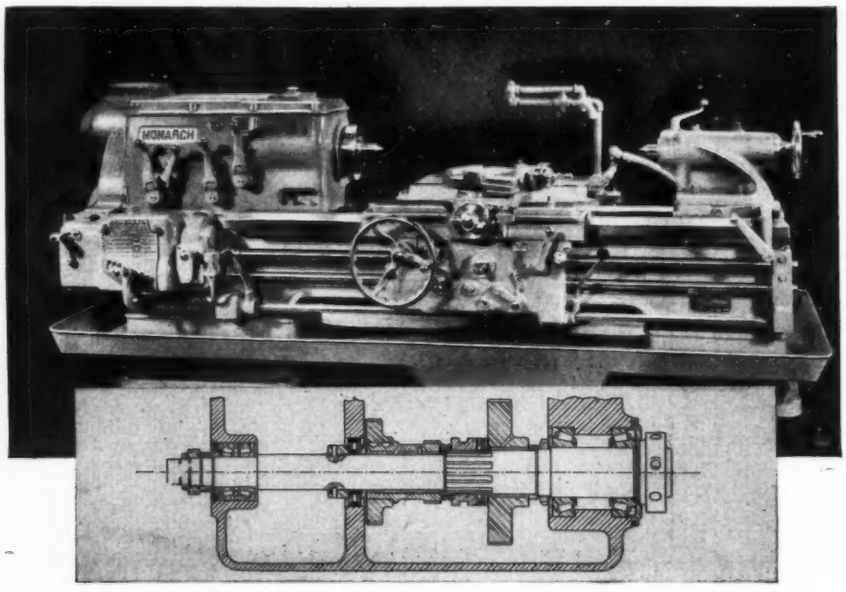


A LARGE PRECISELY CONSTRUCTED ROLLER THRUST BEARING, measuring over a foot in diameter, enables the giant 5½-ton hook, shown in the inset, to rotate smoothly and safely, even when encumbered by its 150-ton capacity load. When the Shepard Niles Crane and Hoist Corporation custom-designed this load block, which is to hang from an overhead electric traveling crane in a West Coast shipyard, they selected a Type LR-71 Roller Thrust Bearing for the yoke bearing because of its compact design which provides a static capacity of 155 tons. This is an excellent example of Torrington's ability to design and build bearings for unusual applications.

FILING SAW TEETH on hand, band and circular saws for the Army Air Corps is the destiny of these Automatic Saw Filers built by the Foley Manufacturing Company. The precise action needed to obtain accurate file cuts depends to a large extent upon the use of compact, high capacity NCS Needle Bearings.



GRINDING OF GEARS, WASHERS and rolls is done rapidly and accurately with this Rotary Surface Grinder made by the Arter Grinding Machine Company. In the four-speed change gear mechanism for the drive to the magnetic chuck, the makers have specified Type NCS Bearings with their compact design and high load capacity. Bearing application is shown in the accompanying cross-section.

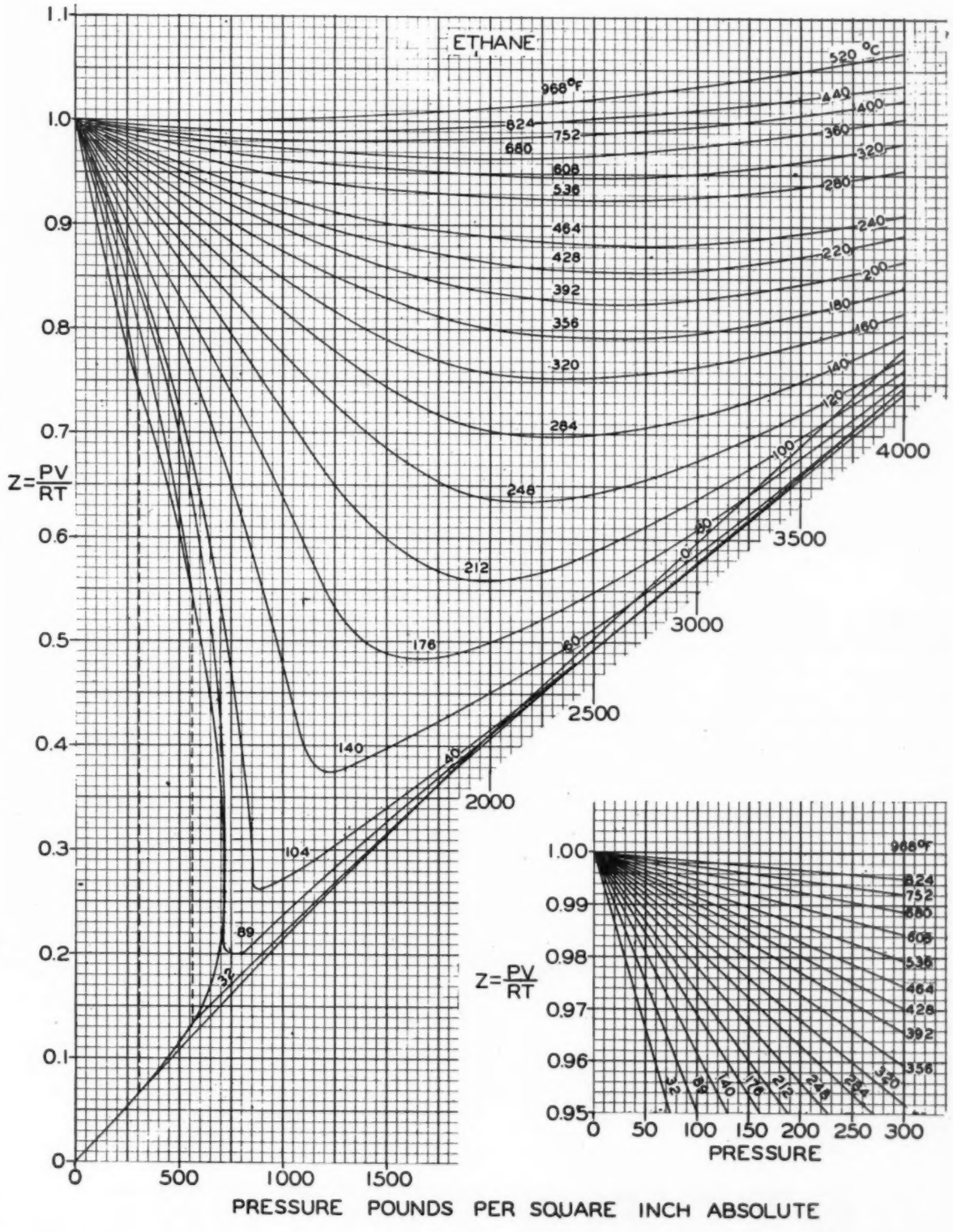


NEW STANDARDS OF ACCURACY and performance in metal turning have been developed through the generous use of anti-friction bearings in this Model "M" 16-Speed Engine Lathe built by The Monarch Machine Tool Company. Giving high capacity in a minimum of space, Torrington Radial Roller Bearings have been used as the center support of the spindles of these lathes, as shown graphically in the accompanying cross-section.

BECAUSE OF THEIR LIGHT WEIGHT, low coefficient of friction and high lubricant capacity Needle Bearings serve a wide variety of special applications. If you have a seemingly difficult bearing problem, it may be solved quickly and easily by reference to Torrington-Bantam's complete line of Needle Bearings of all types and sizes. Whatever your bearing problem, TURN TO TORRINGTON for expert engineering counsel.

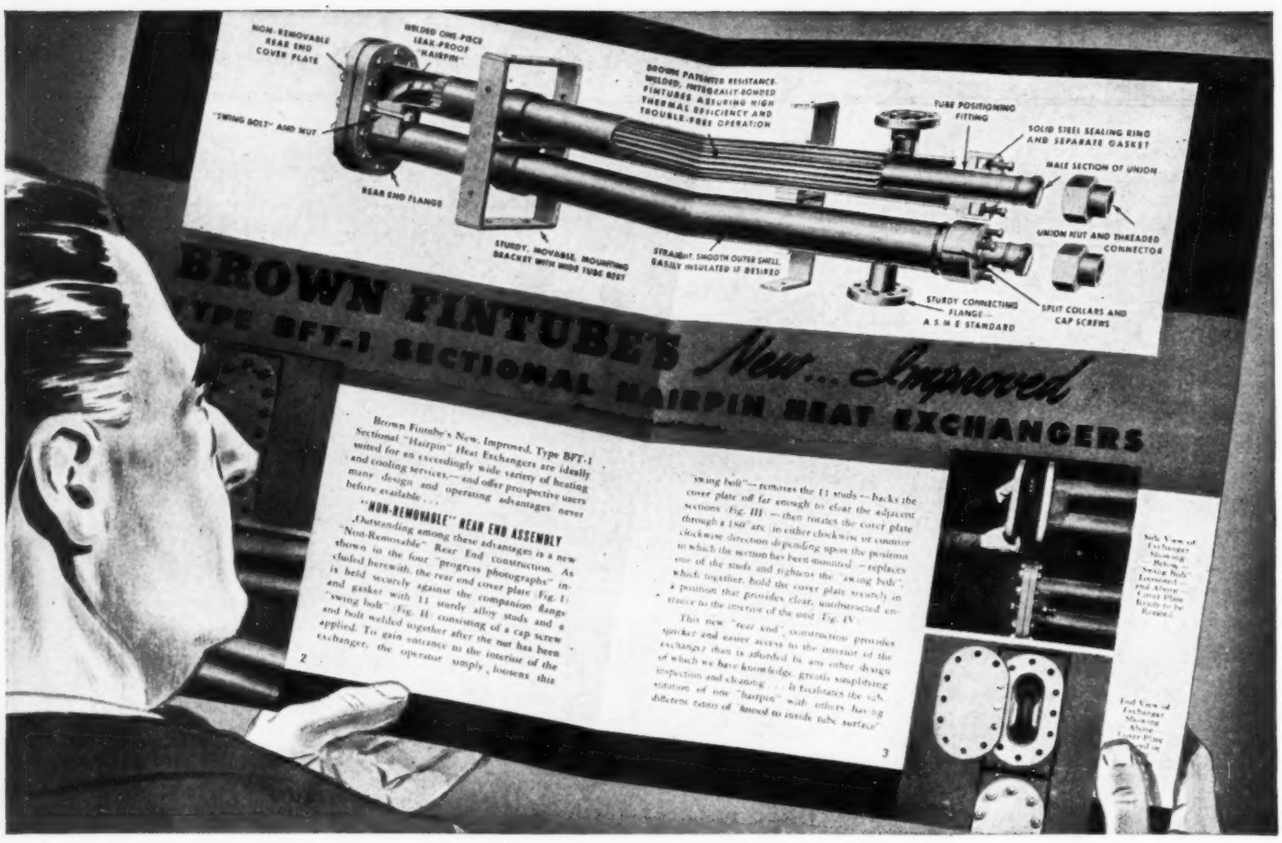
ARMY NAVY
TORRINGTON BEARINGS
STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL
THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION
SOUTH BEND 21, INDIANA

Compressibility Factors for Ethane at Absolute Pressures and Temperatures



*Can be filed under P 621.003

—Chart by George Granger Brown, University of Michigan.


BROWN FINTUBE'S New... Improved
TYPE BFT-1 SECTIONAL HAIRPIN HEAT EXCHANGERS
NON-REMOVABLE REAR END COVER PLATE
WELDED ONE-PIECE LEAK-PROOF "HAIRPIN"
"SWING BOLT" AND NUT
REAR END FLANGE
BROWN PATENTED RESISTANCE-WELDED, INTEGRALLY-BONDED FINTUBES ASSURING HIGH THERMAL EFFICIENCY AND TROUBLE-FREE OPERATION
TUBE POSITIONING FITTING
SOLID STEEL SEALING RING AND SEPARATE GASKET
MALE SECTION OF UNION
UNION NUT AND THREADED CONNECTOR
STURDY, MOVABLE, MOUNTING BRACKET WITH WIDE TUBE REST
STRAIGHT, SMOOTH OUTER SHELL, EASILY INSULATED IF DESIRED
STURDY CONNECTING FLANGE — A.S.M.E. STANDARD
SPLIT COLLARS AND CAP SCREWS

FREE ON REQUEST

BULLETIN 432 GIVES FULL DETAILS

• Engineers, works managers and operating men in all plants having heating and cooling problems, will want a copy of Bulletin No. 432... It gives full details of the new "sectional" heat exchangers that give users many advantages never before obtainable...

Outstanding among these new features is a "Non-removable" rear end assembly—see views above—that provides quick, easy access to the interior of the exchanger. This construction greatly simplifies inspection and cleaning—facilitates the substitution of one "hairpin" with others to secure optimum operation in different duties—and is of particular advantage when the exchangers are mounted high overhead, since it avoids the use of bell housings or other heavy members, and the work of removing these, lowering them to the ground, raising them back up, and putting them on again, for even the most routine inspection.

The new "head seal" is compact—holds the tube and shell in proper alignment—avoids any outboard stress or strain,—and can be assembled easily with a standard wrench.

Other advantages are welded one-piece "hairpins",—the use of Brown resistance-welded, integrally-bonded Fintubes as the heat transfer medium—and —and— But get the *complete* story, together with dimensions of standard sizes, performance data, etc. It's all in Bulletin 432. Send for a copy today!

Brown integrally-bonded Fintubes are used in all Brown Fintube Heat Exchangers,—are available in exchangers made by most other manufacturers,—and are ideally suited for many other heating and cooling services. Furnished in plain "longitudinal" or "cut and twisted" types,—wide range of sizes, in low carbon or special steels. Design assistance furnished gladly.

THE BROWN FINTUBE CO.

· 125 FILBERT STREET • ELYRIA, OHIO

MANUFACTURERS OF INTEGRALLY BONDED FINTUBES AND FINTUBE HEAT EXCHANGERS

After being welded the pipe was supported on skids above the ditch. The next step was cleaning and priming, after which coating and wrapper were applied

PETROLEUM ENGINEER Exclusive Feature

by
Frank H. Love
Managing Editor

Constructing the WEP Products Line

☆ Methods employed in laying companion line to the "Big Inch"

WITH laying of the pipe completed and the line now being tested with water, War Emergency Pipelines' 20 in. carrier to move products from Gulf Coast refineries to terminals in the East will go into operation prior to the first of the year. Some of the pumping equipment has yet to be installed but enough stations are in operating condition to make possible the use of the system in the immediate future.

Completion of this project will consummate the gigantic program for transporting crude oil and finished petroleum products to the eastern seaboard that was set in motion June 10, 1942, when the War Production Board agreed to allocate steel for the crude oil line popularly called the "Big Inch."

Subsequently the first section of the products line was approved and 173,750 tons of steel allocated for its construction. This was on January 26, 1943. This portion of the line consists of 62 miles of 16 in. feeder lines and 824 miles of 20 in. mainline, to Seymour, Indiana. The original estimate of cost was $44,000,000.

On April 2, 1943, allocation of 113,250 tons of steel was made for the extension of the line from Seymour to the East. Estimated to cost $31,000,000, this portion of the line is 651 miles in length, all pipe being 20 in. in diameter.

In constructing the line War Emergency Pipelines, Inc. acted as agent for the owners, Defense Plant Corporation. Operation also is by WEP acting as agent for Defense Supplies Corporation, another subsidiary of Reconstruction Finance Corporation.

Rated capacity of the line is 235,000 bbl. daily. For the rest of this year the system is scheduled to transport kerosine and No. 2 heating oil, after which three grades of gasoline are scheduled. Operating pressure will be between 725 and 820 lb. per sq. in.

Construction Methods

The main line originates at Beaumont, Texas. Feeder lines bring products to this point from a group of refineries in the Gulf Coast area. The 20 in. line extends in a northeasterly direction to Little Rock, Arkansas, and from there on to the East occupies the same right-of-way as the "Big Inch" crude oil line.

Despite numerous difficulties, exceptionally good time was made in the laying of the line. In this respect statistics giving the miles completed by months, including mainline, feeder, and branch delivery lines, are of interest. In April, the month that saw the work barely get underway, only 3 miles of pipe was laid. In May this was increased to 78 miles, and from then on crews were operating at a normal pace, as follows: June, 224 miles; July, 333 miles; August, 396 miles; September, 308 miles; October, 171 miles, and November, 120 miles. The record completion by all crews in one working day was 19.91 miles on August 17. The record completion by one crew in a single day was 4.09 miles on August 20.

The pipe trench on an average was cut 34 in. wide and 4½ ft. deep, conventional type ditching machines being used. In solid rock and on mountain sides lesser depths were permitted, and in such instances blasting and the use of backhoes and draglines were utilized extensively.

Field joints were made by electric welding, 3 and 4 beads being run. Average speed of the welders was 1.2 welds per hour per welder, and approximately 5 lb. of welding rod was required for each circumferential weld.

Both the roll welding method and the stove-pipe method of construction were employed. Choice of the method used rested entirely with the individual contractor and was determined by his particular equipment and workmen, the

Heavy duty tractors were required to handle the large-diameter pipe

terrain on his section also entering into consideration.

River Crossings

A total of 36 crossings was made of navigable rivers and streams. Construction methods were varied to cope with conditions peculiar to each particular job. Government regulations prescribe that pipe lines across any navigable stream be laid at a certain depth below river bottom, usually 4 to 5 ft. In the case of smaller streams the pipe trench was dug with dragline and clamshell buckets. Across the wider streams excavations were made with suction type dredges. Many of the rivers from the Mississippi eastward to the Delaware have rocky beds and a considerable amount of blasting was required. A notable example was the Susquehanna River, on which crossing 65 tons of dynamite was used.

In constructing the wider crossings it was necessary to lay from barges. The first step in this operation was to apply a triple coating and wrapping to the pipe on shore, after which two 40 ft. joints were welded together to make an 80 ft. length of pipe. These 80 ft. sections were then loaded on a barge equipped with a crane, which was towed into the river and secured to the laying barge. On the latter a ramp had been built at an angle of 30-35 deg. and by means of a crane the pipe sections were lifted onto this ramp. The ends were lined up by use of a clamp, the weld made, and reinforcing sleeves installed. Over the sleeves coating and wrapper were applied. The 20 in. pipe has a buoyancy of 71 lb. per lineal ft. and on all submerged sections 4800 lb. clamps were spaced at close enough intervals (approximately every 30 ft.) to produce a negative buoyancy of 45 to 50 lb. per sq. ft.

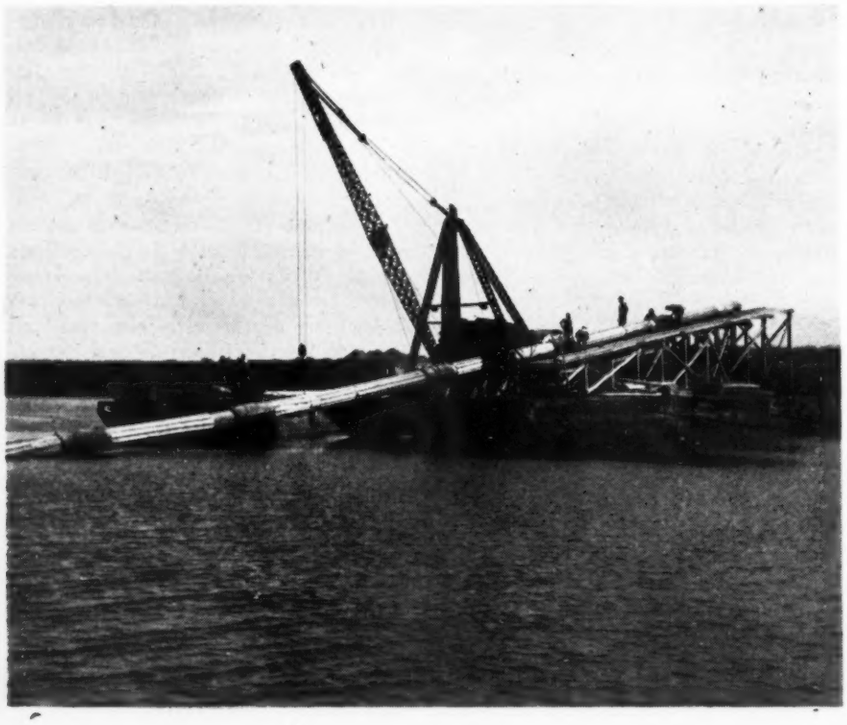
The pipe was lowered by towing the laying barge forward, easing the pipe down the ramp into the water. Slats wired to the pipe prevented damage to coating and wrapper during this operation.

Narrower crossings were made with greater facility. Although equally as great precautions were taken to protect the coating, reinforce the welds, weight the pipe properly, etc., it was not necessary to use barges. In these instances the pipe usually was pulled from the "make-up" bank of the river to the opposite shore by tractors equipped with winches, the pipe being supported by buoys until ready to be lowered.

Coating and Wrappings

An electro-resistivity survey was made throughout the length of the line to determine where continuous coating was necessary and where spot coating would provide adequate protection. Except for the Neches River marshes, the line from Beaumont to Central Ohio, and all pipe in the branch and distribution lines east of Phoenixville, Pennsylvania, is protected with a continuous coating of hot coal tar enamel and asbestos felt wrapper over a coal tar primer paint applied cold. Between Central Ohio and Phoenixville the line is spot coated, this protection being needed particularly in the vicinity of coal mines.

Feeder lines in the Gulf Coast area, including the 16 in. line from Baytown to Beaumont, and also the main 20 in. products line across the Neches marshes, are protected with somastic coating. This asphalt-mastic type coating was applied in central plants or yards prior to stringing. The only application in



The wider river crossings were laid from barges

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OKLAHOMA CONTRACTING COMPANY

DALLAS, TEXAS

Tips on Secondary Recovery

"The real problem in secondary recovery is economic rather than physical, because the success of a project is based upon the profit made, and not simply on the oil recovered."

—From paper by George H. Fancher, presented before A.P.I. Chicago, November 8-11, 1943.

"There are partly depleted oil pools that have not responded to water flooding in which profitable secondary-recovery operations using air or gas injection have been conducted. Connate-water-to-oil ratios in the sands of these pools may be such that these are more permeable to water than they are to oil and, therefore, yield only water when subjected to a water drive."

—From paper by Charles R. Fettke, Park A. Dickey, Douglas Rogers, Jr., Paul D. Torrey, and C. J. Wilhelm, presented before A.P.I. Chicago, November 8-11, 1943.

"Although water flooding under certain conditions has been demonstrated to be more effective in the recovery of oil than repressuring by air or gas injection, there is usually a greater percentage of the residual oil content of the reservoir, after the primary recovery phase, left in the reservoir after water flooding than is recovered by this secondary method."

—From a paper by Paul D. Torrey, presented before the A.P.I. Chicago, November 8-11, 1943.

the field was to the joints after the welds had been made.

The hot enamel, on the other hand, was applied in the field to a thickness of 3/32 in. by a traveling type machine that performed this operation and the application of the asbestos felt wrapper as a single function. On the latest machine of this type the hot enamel is pumped to the coating head through a flexible metallic hose attached to the "dope" kettle, a considerable improvement over the older method of manually carrying the dope from the kettle to the hopper of the coating machine.

Primer was applied ahead of the coating and wrapping by a self-propelled combination pipe cleaning and priming machine.

Pipe Bending

Experience gained from laying the 24 in. crude oil line stood construction crews in good stead in the matter of making bends on the products line. In the former case difficulty was encountered in bending the large diameter pipe to fit the contour of the ground. Welded sections could be bent cold, but in the early stages of construction many of the contractors did not have proper equipment to bend single joints cold and had to resort to heating, a slower procedure. Subsequently a pipe bending rig was developed, which was used in completing the crude oil line and was also utilized in the laying of the products line. One rig was provided for each construction crew. The bending machine, or "jig," consists of a series of adjustable shoes that fit the pipe. After the pipe is placed in the machine tractors provide the power to pull the pipe to the desired bend.

Contractors

General contractors who laid the products line consisted of the following:

Williams Brothers Corporation, 57 miles of feeder lines and 240 miles of 20 in. main line.

Sharman and Allen, 62 miles of 16 in. connecting line and 41 miles of feeder line.

N. A. Saigh Company, 71 miles of 20 in. main line.

Winston-Guthrie-Brown, 31 miles of 20 in. main line.

Anderson Brothers, 56 miles of 20 in. main line.

B. & M. Construction Company, 101 miles of 20 in. main line and 51 miles 8⅝ in. O. D. branch line.

Oil States Construction Company, 61 miles of 20 in. main line.

Swinerton-Walberg and Company, 64 miles of 20 in. main line.

Midwestern Engineering and Construction Company, 29 miles of 20 in. main line.

Sheehan Pipe Line Construction Company, 41 miles of 20 in. main line.

J. C. Truman Construction Company, 87 miles of 20 in. main line.

Ray L. Smith Construction Company, 96 miles of 20 in. main line.

C. S. Foreman Company, 106 miles of 20 in. main line.

Bechtel-Dempsey-Price, 80 miles of 20 in. main line.

I. C. Little, 44 miles of 20 in. main line.

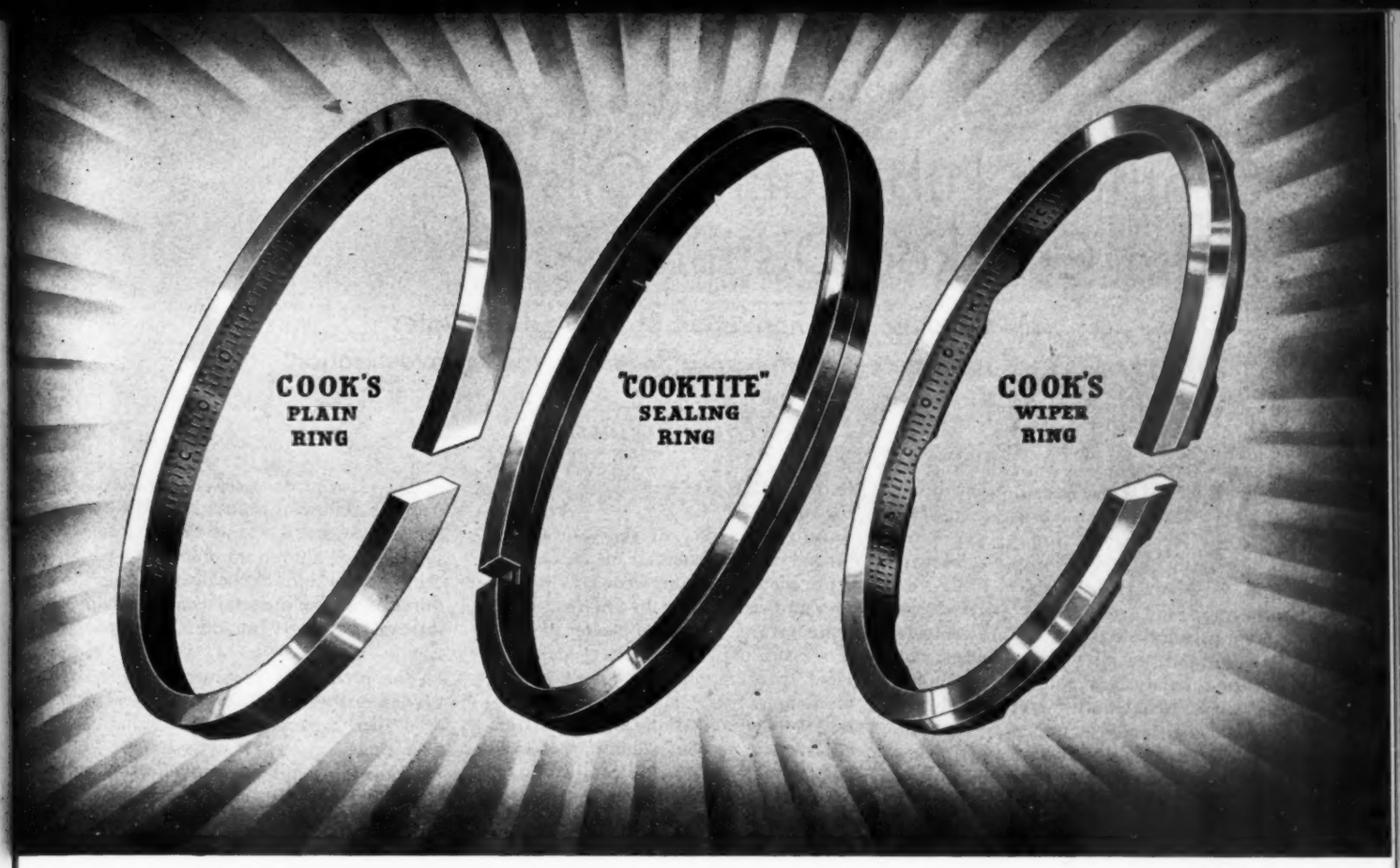
O. C. Whitaker Company, 45 miles of 20 in. main line.

Oklahoma Contracting Company, 200 miles of 20 in. main line.

Eastern Construction Company, 41 miles of 20 in. main line.

—— ☆ ☆ ☆ ——

Welders usually worked in pairs to make the finishing welds



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Synthetic Lubricating Oils From Cracked Distillates*

☆ Catalytic polymerization of cracked distillates from ceresine and paraffin employed in investigation

by M. G. Mamedli

MANY scientists in the United States and in Russia are investigating the preparation of synthetic lubricating oils. The British scientists, A. W. Nash, H. M. Stanley, and A. R. Bowen,[1] investigated the polymerization of ethylene under various temperatures and pressures in the presence of various catalysts. F. Sullivan et al[2] prepared synthetic lubricating oils by means of catalytic polymerization of olefins and other unsaturated hydrocarbons and cracked distillates.

In Russia a very interesting investigation dealing with the preparation of synthetic lubricating oils by catalytic polymerization of cracked distillate was carried out by L. G. Zherdeva.[3] The raw material used for cracking was white and match paraffin wax, Foot's oil, and slack wax from the paraffin unit. L. A. Gukhman[4] obtained synthetic lubricating oils of a good color and low pour point by catalytic polymerization of the Baku cracked distillate, but the viscosity index curve of the oils obtained was too steep.

The purpose of the investigation was to prepare synthetic lubricating oils by catalytic polymerization of the cracked distillate from ceresine (known locally as Surakhany "plug" because it plugged walls and pipes) and from paraffin, and to compare the properties of the synthesized oils.

Experimentation

It is known that the polymerization of ethylene and other olefins to lubricating oils can be achieved through the action of ultraviolet rays, silent electric discharges, pressure, temperature, and the use of catalysts, and through different combinations of these factors. In the present work the synthetic oils were obtained through joint action of the last two factors, i.e., by the use of heat and the application of a catalyst.

The following raw materials were used in the experiments: (1) pressure distillate from a Winkler-Koch cracking unit operating on the usual raw materials, i.e., Surakhany topped crude oil, and (2) cracked distillates obtained by cracking the Surakhany "plug" and Grozny white paraffin wax in a laboratory unit.

As the velocity of the reaction increases with the increase of the temperature the time required for polymerization can be reduced by increasing the temperature, which is a matter of great interest from the practical point of view. Information on the most favorable temperatures required for the process of polymerization as indicated in the literature is contradictory, however.

Although Nash[1] and Sullivan[2] recommend 50 to 70°C. as the most favorable temperature, there are indications that the polymerization of low-boiling olefins to lubricating oils should be carried out at a temperature of the magnitude of 125° to 130°C.[11]

L. A. Gukhman,[6] while carrying out experiments with the same raw material (cracked distillate from the Vickers unit) arrived at the conclusion that the polymerization of the cracked distillate to synthetic lubricating oils in the presence of aluminum chloride takes place not only at relatively low temperatures, of the magnitude of 50° to 60°C., but also at temperatures that are considerably higher, i.e., of the magnitude of 115° to 130°C., and for both temperature ranges the quality of the oil obtained was virtually the same.

Because the statements made in the literature regarding the most favorable temperatures for carrying out the process of polymerization are contradictory, it was decided to investigate simultaneously the influence of temperature on the quality and the yields of synthetic lubricating oils obtained by polymerization.

The experiments were conducted under the following conditions: Process temperatures, 65° and 125°C., consumption of aluminum chloride, 3 percent of the weight of the distillate, and a duration of the process, using mechanical agitation of 30 hr. and 3 hr., respectively.

The process of polymerization was carried out in a cylindrical iron vessel of 3 liter capacity having a spherical bottom and provided with a tight lid with openings for the propeller and a bulb condenser for the condensation of the light fractions. A cooler was connected to the receivers of the uncondensed hydrocarbon vapors. The propeller was operated by a heat motor at a velocity of 100 to 110 r.p.m. Aluminum chloride was introduced into the reaction agitator in the form of a fine powder.

Two types of products were obtained in the agitator after the process of polymerization was completed: The upper layer was a solution of oil in saturated hydrocarbons, and the lower layer was a complex combination of the oil with aluminum chloride. The upper layer had a bluish color, was strongly fluorescent, and had a hydrogen chloride odor. The upper layer was separated from the lower layer and neutralized with a dilute solution of caustic. The bluish color of the solution changed to a light straw color during the neutralization process. The neutralized solution was washed with water and then distilled with superheated steam from a small iron still, followed by its concentration in a small flask with superheated steam or under vacuum to the

TABLE I
Physical chemical properties of cracked distillates

Properties	Surakhany "plug"	Grozny paraffin
d_{15}	0.783	0.7675
Aniline point	52.4°	60.5°
Engler distillation		
I.B.P.	146°C.	150°C.
Distilled over below 175°C.	27%	7%
Distilled over below 200°C.	51%	39%
Distilled over below 225°C.	72%	75%
Distilled over below 250°C.	87%	94%
F.B.P.	260°C.	265°C.
Residue	1.5%	1.5%
Losses	11.5%	4.5%
Hydrocarbon composition		
Unsaturated hydrocarbons	46.93%	45.24%
Aromatic hydrocarbons	8.00%	6.66%
Naphthene hydrocarbons	10.00%	32.5 %
Paraffin hydrocarbons	35.07%	15.60%

*Translated from the Russian oil journal *Zhurnal Prikladnoi Khimii* (Journal Applied Chem. U.S.S.R.) *16*, No. 3-4, 1943, pp. 143-150 by A. A. Boehtlingk, Berkeley, California.

Sub-Surface Facts

o. 6 | 1943 | DALLAS, TEXAS

TIS TYPE G (Side Door) HOKE SIMPLIFIES THE OMPLETION & PRODUCTION F TWO ZONE WELLS...

lakes Possible the Taking of ottom Hole Pressures of Each Zone ndependently of the Other

The Otis Type G Side Door Choke has been enerally accepted by the oil industry as tandard equipment for use in completing nd producing two-zone flowing wells.

The Side Door Choke provides a means o positively open and close circulating orts above a packer without moving the ubing string or breaking the packer seal. his makes it possible to set the packer, nd the tubing and permanently hook-up he surface connections before bringing in he well, thereby greatly facilitating two-one completion operations.

The Side Door Choke provides a means o actually record, with a regular bottom ole pressure gauge, the formation pressure f the upper zone independently of the ower zone. This can be done without mov-ng the tubing string or resorting to uncer-ain calculations.

The complete operation is performed nder pressure with the same steel measur-ng line used to run the bottom hole pres-ure gauge and requires only three to four ours.

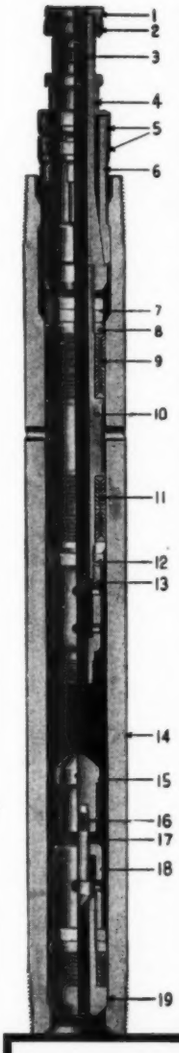
OTHER USES OF SIDE DOOR CHOKE ASSEMBLY

The Otis Side Door Choke also provides a means to accomplish the following:

- To acidize either zone of a two-zone well independently from the other zone.
- To recondition mud back of the packer without exposing the pay zone to the mud column.
- To take bottom hole samples from either zone of two-zone well.
- To serve as a removable jet collar in a gas-lift operation.

SERVICE—Otis Pressure Control maintains experienced crews and service trucks for the installation of all Otis Sub-Surface Tools.

NEW V-TYPE ASBESTOS BASE PACKING ON OTIS SIDE DOOR CHOKE



1. Retaining Nut
2. Set Screw
3. Mandrel
4. Slip Carrier
5. Bands
6. Locking Dogs
7. Upper Split Packing Nut
8. Packing Ring
9. Upper Chevron Packing
10. Side Bean Packing Mandrel
11. Lower Chevron Packing
12. Lower Packing Nut
13. Bean Cage
14. Landing Nipple
15. Nut
16. Rivet
17. Drop
18. Valve Cage
19. Cup Mandrel

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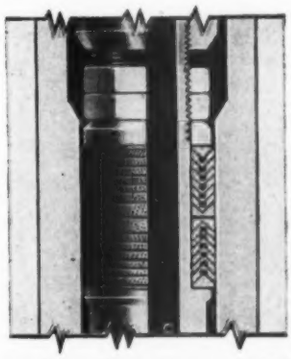

being used on Otis Type G Side Door Chokes.

The change was made advisable after difficulty was encountered with the former valve cups in certain deep high pressure distillate wells. Under extremely high temperature and high pressure conditions, both the fabric and the bonding material in the former choke cup were subject to deterioration.

The new V-Type packing completely overcomes this difficulty. Made of many layers of asbestos cloth bonded by a cementing material that resists acids, it is strong enough to withstand any well pressure or temperature encountered. The new packing has $\frac{3}{4}$" thickness, whereas the old type was only $\frac{3}{16}$" thick, increasing its strength in the same proportion.

The Type G Side Door Choke with the new packing element assures positive performance regardless of bottom hole temperatures or pressures.

OTIS PRESSURE CONTROL, INC.
DALLAS, TEXAS

desired viscosity. The resultant distillate was naptha-kerosine and light lubricating oil fractions; in the residue were more or less viscous oils depending upon the depth of the concentration. It should be pointed out that with the use of superheated steam the deeper the concentration the brighter the oils and the more complete the removal of the lighter products. The oils obtained have a considerably better color if the upper layer is removed from the lower layer immediately after cooling at the end of the polymerization process. If the upper layer is not removed for a number of hours, then the oil obtained is considerably darker, probably because the resinous substances are transferred from the lower to the upper layer. The lower layer is a semi-liquid resinous layer that hardens rapidly in the air. It is a complex combination of aluminum chloride with hydrocarbons, although its appearance resembles that of acid sludge obtained in the refining of lubricating oils.

According to Nash,[1] the residue obtained in the polymerization of ethylene is a complex combination of aluminum chloride and oil, the hydrocarbons of which are poorer in hydrogen than the basic oil in the solution. According to Nash, an oil of olefinic character is obtained when decomposing the residue obtained in the polymerization of ethylene in the presence of aluminum chloride with ice water. This observation by Nash is completely confirmed by the experiments reported here, as will be shown later. The precipitate obtained in the experiments, however, which were carried out at 125°C. (when treated with ice water) did not give an oil, but a heavy black tar having a specific gravity of $d_{15} = 0.970$.

From the precipitate obtained in the polymerization of the cracked distillate from the Grozny paraffin an oil of a peculiar odor separated out when the precipitate was decomposed with ice water. The oil was darker in color than the basic oils obtained from the upper layer. The fundamental properties of the oil were: $d_{15} = 0.891$, E_{100} (Engler) viscosity 2.22, E_{10} viscosity 30.61, open crucible (Brenken) flash 274°C., and pour point minus 16°C.

The properties of the concentrate obtained in the polymerization of the Winkler-Koch cracked distillate are given in the following tabulation.

Polymerization conditions: Temperature 125°C. and duration of agitation 3 hr.

Characteristics of the concentrate

d_{15}	0.944
E_{100} viscosity	2.32
E_{50} viscosity	21.7
n37.8°C.	— 1.2418
n98.9°C.	— 0.08632
Viscosity index	15.6
Flash (Brenken)	215°C.
Conradson C	0.67%
Acidity in % SO_3	0.006%
Color (Dubosc colorimeter)	12 mm.
Pour point	—15°C.

These tabulated data show that synthetic oils obtained from the usual cracked distillate from the Winkler-Koch cracking unit are of a low quality, as they are characterized by a high specific gravity, a steep viscosity-temperature curve, and a relatively low flash point.

Their low quality may be the result of the high content of aromatic hydrocarbons in the distillates, which is understandable because the product obtained from the unit is a pressure distillate. When aromatics are present in the pressure distillates, treatment with aluminum chloride proceeds not only along the line of polymerization of unsaturates and their isomerization but a condensation of the unsaturates with aromatics takes place that affects adversely the properties of the synthetic lubricating oil.

Taking into account the information available in the literature, namely that the quality of the synthetic oil depends upon the conditions of cracking, as well as those of polymerization, some special experiments were made. Samples of Surakhany "plug" and Grozny white paraffin were used as raw materials. Both products were subjected to cracking down to coke at atmospheric pressure under identical conditions and the distillates obtained were subjected to polymerization at 65° and 125°C.

The results of cracking the Surakhany "plug" and the Grozny paraffin

TABLE 5

No. of experiment	Product	d_{15}	E_{50}	Color	Pour point, °C.	% Yield on distillate
1	Oil distillate obtained in the concentration of oil No. 1 (Table 2)	0.893	1.49	28.5	— 2	11.9
2	Oil distillate obtained in the concentration of oil No. 2	0.8672	2.8	40	— 20	11
3	Oil distillate obtained in the concentration of oil No. 3	0.8052	2.56	above 50	— 20	10.37
4	Oil distillate obtained in the concentration of oil No. 4	0.8152	1.52	40	— 20	9.7
5	Oil distillate obtained in the concentration of oil No. 5	0.8472	5.71	40	— 20	10.25

TABLE 2

No. of experiment	Raw material used in synthesis	Conditions of polymerization Temp. °C.	Conditions of polymerization Duration in hr.	Percent yield of main oil on cracked distillate
1	Pressure distillate from the Winkler-Koch unit	125	3	7.9
2	Cracked distillate from the Surakhany "plug"	65	30	20.66
3	Cracked distillate from the Surakhany "plug"	125	3	22.7
4	Cracked distillate from the Grozny white paraffin	65	30	17.7
5	Cracked distillate from the Grozny white paraffin	125	3	18.44

Analysis of oil d_{15}	E_{100}	E_{50}	Percent C (Conradson)	Brenken flash, °C.	Pour point °C.	Dubosc color	Acidity in % SO_3
0.944	2.32	21.7	0.71	215	— 15	12	0.006
0.8831	3.3	22.47	0.436	282	— 20	5	0.006
0.8846	0.03	22.31	0.59	278	— 20	4	0.006
0.8644	3.78	22.59	0.494	308	— 20	3	0.006
0.8582	3.14	17.79	0.19	292	— 20	12	0.009

TABLE 3

Consec. No.	Oil	E_{50}	E_{100}	Sligh No.
1	Synthetic lubricating oils from the Winkler-Koch unit	21.7	2.32	3.7
2	Synthetic lubricating oils from the Surakhany "plug"	22.47	3.3	2.9
3	Synthetic lubricating oils from the Surakhany "plug"	22.31	3.03	0.8
4	Synthetic lubricating oils from paraffin wax	22.50	3.78	0.8
5	Synthetic lubricating oils from paraffin wax	17.79	3.14	1.75

TABLE 4

No. of experiment	Products	d_{15}	Saybolt viscosity* 100°	Saybolt viscosity* 210°	Viscosity index
1	Synthetic oil from the Winkler-Koch unit	0.944	1170	72	15.6
2	Synthetic oil from the Surakhany "plug"	0.8831	1551	108	89.0
3	Synthetic oil from the Surakhany "plug"	0.8846	1482	104	87.0
4	Synthetic oil from Grozny white paraffin wax	0.8644	1443	125	112.0
5	Synthetic oil from Grozny white paraffin wax	0.8582	1110	106	112.0

*W. B. McCluer and M. R. Fenske. *Ind. Eng. Chem.* 27 82-86 (1935).

Viscosity in stokes at 57.3°	Viscosity in stokes at 98.9°	Viscosity weight constant	Molecular weight	Ultimate analysis % C.	Ultimate analysis % H
2.570	0.1330	0.8865	380	88.29	11.70
3.3378	0.2254	0.7972	—	86.35	13.75
3.1934	0.2162	0.7999	—	86.11	13.53
3.1080	0.2638	0.7698	—	85.77	14.07
2.3940	0.2212	0.7645	—	85.87	14.09

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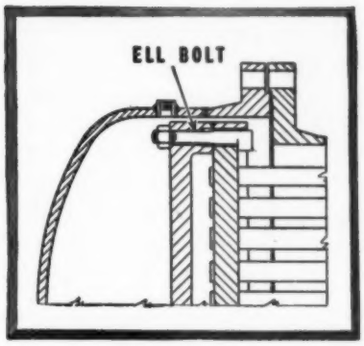

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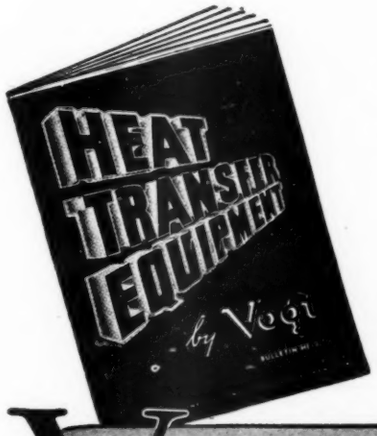

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"Independent operators say it is becoming more difficult every day to find a rig available for immediate drilling. If the rigs were available, there would be a big drilling campaign under way now on the gulf coast."

—Weldon Hill, oil editor, Houston (Texas) Post.

"It is not so much of a job to obtain material and places to drill, as it is men to man the crews that actually do the drilling. Every contractor that we know of is crying for men, and many outfits are drilling with skeleton forces." —W. G. Skelly, president, Skelly Oil Company.

"Associated with the discovery problem is the pressing problem of incentives to prospect, and the subject of an overall increase in the price ceiling for crude oil has been vigorously urged by the petroleum administration for war with the full support of the industry." —William Boyd, Jr., president, A.P.I.

are given in the following tabulation:

Surakhany "plug"

A. Cracking

Taken for cracking	12,000 g.	
Obtained wide fraction	10,872 g. or	90.6%
Coke	480 g. or	4.0%
Gas and losses	648 g. or	5.4%
Total	12,000 g. or 100	%

Beginning of cracking of the Surakhany "plug" 382°C., end 418°C.

B. Distillation of the wide fraction

Taken for distillation	10,400 g.	
Obtained fraction b. below 140°C.	1,165 g. or	11.2%
Obtained fraction at 140 to 250°C.	2,912 g. or	28 %
Obtained fraction above 250°C.	5,460 g. or	52.5%
Losses	863 g. or	8.3%
Total	10,400 g. or 100	%

Grozny white paraffin

A. Cracking

Taken for cracking	14,000 g.	
Wide fraction obtained	13,104 g. or	93.6%
Coke	182 g. or	1.3%
Gas and losses	714 g. or	5.1%
Total	14,000 g. or 100	%

Beginning of cracking of Grozny paraffin 393°C., end 424°C.

B. Distillation of wide fraction .

Used for distillation	12,765 g.	
Obtained fraction b. below 140°C	1,570 g. or	12.3%
Obtained fraction at 140 and 250°C.	3,434 g. or	26.9%
Obtained fraction, above 250°C.	6,727 g. or	52.7%
Losses	1,034 g. or	8.1%
Total	12,765 g. or 100	%

The distillation of the wide fraction obtained in the cracking of the Surakhany "plug" as well as the Grozny paraffin was carried out in an iron still with a Gadaskin fractionation tower.

The characteristic of the distillates obtained in the cracking of the Surakhany "plug" and the Grozny white paraffin and taken for the synthesis are given in Table 1.

Polymerization

Cracked distillates from the Surakhany "plug" as well as those from the Grozny white paraffin were subjected to polymerization with aluminum chloride under the following conditions: (1) at a temperature of 65°C. and 30 hr. of agitation, and (2) at a temperature of 125°C. and 3 hr. of agitation.

In both cases 3 percent of aluminum chloride on the basis of the weight of the distillate was used.

The results obtained are summarized in Table 2.

An investigation of the principal synthetic lubricating oils has shown that these oils are characterized by exceptionally high grade properties. Table 2 contains yields and analyses of synthetic lubricating oils obtained from various cracked distillates.

The majority of oils that were obtained required almost no refining, as they have a good color and relatively low carbon numbers. During the determination of the pour point the synthetic oils prepared from the paraffinic raw material remained transparent and fluid at minus 20°C.

It is known that the flash point of an oil is closely related to its fractional composition. The best oils, at the same viscosity, are oils having high flash points, which give the lowest losses when heated. The synthetic lubricating oils that were obtained from ceresines and particularly those from paraffins have high flash points of the magnitude of 280-308°C., and show that synthetic oils obtained from ceresine and paraffin are composed of high boiling point hydrocarbons and are characterized by a low evaporation, which is most important under operating conditions.

One of the greatest disadvantages of the synthetic oil is its ability to become oxidized at high temperatures with the separation of a precipitate composed mainly of asphaltenes and carboids.

To evaluate the stability of the obtained synthetic oils the latter were subjected to artificial aging by the Sligh method.

F. Sullivan[2] and L. G. Zherdeva[3] point out that the oxidation of synthetic oils leads to the formation of soluble acids and in this case a residue is not formed.

The synthetic oils that were obtained by the writer were subjected to oxidation by the Sligh method as well as with soluble acids yielding small amounts of a precipitate (Table 3).

The Sligh numbers of our synthetic oils show that these oils are resistant to oxidation and in this respect they excell considerably properly refined high grade lubricating oils.

The change of the viscosity with temperature is of the greatest value in the evaluation of the quality of lubricating oils.

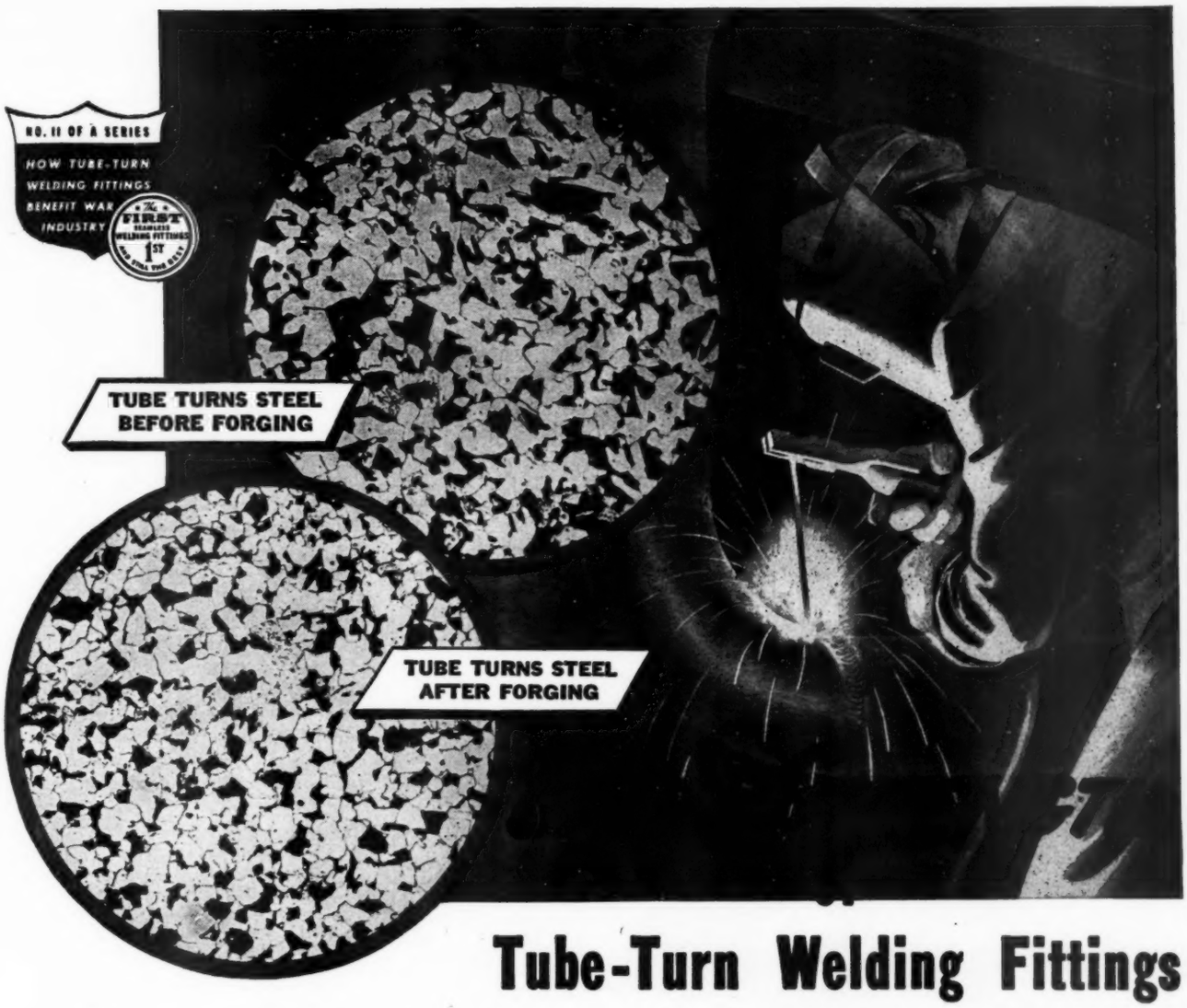
Synthetic lubricating oils that were prepared from paraffin raw material have a very satisfactory viscosity index. In this respect they differ very favorably from the highest grades of natural oils including those from Pennsylvania, as may be seen from Table 4.

The above mentioned charactertistics of synthetic lubricating oils from paraffin raw material, namely, the slope of the viscosity index curve, resistance to oxidation, and the low pour point indicate the homogeneity of the synthetic lubricating oils, which most probably are composed of hydrocarbons of the naphthene type. In the concentration of the polymerizate (in addition to the viscous oil in the residue) there is obtained also a high grade non-viscous oil in the distillate, the amount of which depends upon the depth of distillation. Moreover, the naphtha-kerosine fractions, which are composed mainly of saturated hydrocarbons that were not affected by the process of polymerization, are distilled off. Analyses of an intermediate product obtained in the concentration of the polymerizate are given in Table 5.

The oil distillate obtained in the concentration is of the type of heavy gas oil. It is high grade and may be utilized for special purposes. The quality of the kerosine obtained in the distillation of the polymerizate is relatively satisfactory and the kerosine may be used successfully for illuminating purposes. The

TABLE 6

No. of experiment	Product	d_{15}	Aniline point, °C.	Aniline point after removal of raw material	I.B.P., °C.	F.B.P., °C.	Yield in percent on cracked distillate	Color Stammer scale
1	Distillate in the preparation of oil No. 1 (Table 2)	0.805	58.3	71.4	145	265	70.25	2.09
2	Distillate in the preparation of oil No. 2	0.7768	75	76	165	303	48.15	2.0
3	Distillate in the preparation of oil No. 3	0.7734	75.2	76	157	295	46	1.55
4	Distillate in the preparation of oil No. 4	0.7514	78	83	153	274	41.3	2.3
5	Distilliate in the preparation of oil No. 5	0.7505	78.5	83	156	281	43.3	1.4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last two products do not need any treatment whatsoever.

The fractional composition of the naphtha-kerosine fraction obtained in the concentration of the polymerizate are given in Table 6.

The experiments reported here show that high grade synthetic oils may be prepared from paraffin raw material and that the oils are capable of competing with natural oils. The properties of the synthetic oils depend not only upon the composition of the raw material used in the cracking units but also upon the cracking conditions to which the raw material is subjected. In the cracking conditions most favorable for a maximum yield of unsaturates must be observed. A great influence on the yield of the unsaturates is exercised by the pressure. The higher the cracking temperature the more severe the cracking and, therefore, the higher the aromatization of the cracked product. Aromatic hydrocarbons, however, are not desired for synthetic oils. Basically the process of cracking for the preparation of synthetic lubricating oils must be carried out at low pressures (5 atmospheres) with a prevailing yield of unsaturates in the naphtha-kerosine fraction.

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Conclusion

1. The best lubricating oils, conforming to the standards for aviation oils with respect to the viscosity index, stability to oxidation, low pour point and low specific gravity, as well as a high flash point, are obtained from cracked distillates of paraffin.

2. The process of polymerization of the cracked distillates to synthetic lubricating oils in the presence of aluminum chloride proceeds not only under low temperature conditions of the magnitude of 60° to 65°C. but also at higher temperatures such as 125° to 130°C. The quantitative and qualitative indices are practically identical in both cases. The process of polymerization at high temperature (125°C.) proceeds almost 10 times as fast as at the lower (65°C.) temperature.

3. The quantitative and qualitative indices of synthetic oils depend upon the composition of the cracking stock as well as upon the conditions of cracking. The quality and the yield of the oils improve with the increase in the content of paraffin in the raw material. The process of cracking for the preparation of synthetic crude oils must be carried out at a low pressure, i.e., below 5 atmospheres, at which pressure the maximum yields of unsaturated and a low yield of aromatic hydrocarbons is obtained.

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Earthen Embankment Compaction Tests

☆ **Recently developed techniques for testing and construction result in stability and strength**

by Charles H. Rankin

Consulting Engineer

EARTHEN embankments are used for a great many purposes in the oil fields. Fire walls, burn pits, tank battery settings, and other construction problems involve the use of fills or grades constructed from soil or earth that is at hand. Recent studies by the United States Corps of Engineers, the highway departments of various states, and the railroads have developed a technique for testing soils and have devised methods of construction that will develop grades having the stability and strength requisite for the task that they are to perform.

One of the first comprehensive studies of soil mechanics, instituted by the Corps of Engineers, was begun with a conference held in Boston, Massachusetts, under the direction of Colonel A. K. B. Lyman, June 17 to 21, 1938. The proceedings of this conference were published by the U. S. Engineer's Office, Boston, January, 1939.

The study of soil strength and soil mechanics can be carried to great length and detail both in the field and in the laboratory. It is intended here to present a method for field use that, although it may have its shortcomings, is practicable and is one that is becoming more or less standard for the more common types of earth work; building highway and railroad grades and small dams or embankments.

Early investigations developed the fact that the extent to which a soil can be readily compacted is dependent upon the amount of moisture present in the soil and that the amount of moisture required for ideal compaction varies with the different soil types.

Soil Types

For general field purposes soils may be divided into four general types:

1. **Clay-gumbo:** These soils are the so-called "cohesive," sticky type. They contain on chemical analysis large proportions of clay minerals and organic materials. Test: Any soil which when mixed with water exhibits large percentages of colloidal material.

2. **Silty loam:** These soils occupy a position midway between sandy loam and gumbo soils. They contain considerable proportions of non-soluble materials and smaller amounts of colloidal material. Test: When mixed with water 25 to 50 percent of the material will settle in from 2 to 5 min.

3. **Sandy loam:** These soils, by far the most common, contain considerable proportions of quartz sand. They are only moderately sticky when moistened and drain quickly. Test: 10 to 25 percent of sand will settle in 1 to 2 min. when mixed with water, 75 percent or more of the material will settle in 10 min. and leave a slightly cloudy liquid.

4. **Sandy:** These soils are the so-called "cohesionless" types and consist mainly of quartz sand. Test: When mixed with water will settle as soon as mixing stops.

There are, of course, many variations of the general types given above and it is not uncommon to find two or more in the same borrow pit.

Soil Testing

It is usually the desire of the engineer to build the best possible grade or embankment with the materials at hand. The field tests now in common use are planned to determine as quickly and as efficiently as possible the conditions under which the maximum compaction can be obtained. The apparatus required is inexpensive and readily obtainable.

Apparatus: 1 balance, capacity 70 lb., weighing in lb. and tenths; 1 balance, capacity 1000 g., weighing in g.; 1 container having a capacity of about 1/10 cu. ft., 6 in. dia. by 6 in. deep; 1 container having a capacity of about 0.03 cu. ft., 4 in. diam. by 4½ in. deep; 3 mixing pans, 12 in. by 16 in. by 2½ in.; 6 evaporating pans, 5 in. diam. by 1 in. deep; 1 oven, gasoline or kerosine; 1 small trowel.

Method: Obtain a 25-lb. sample of the material to be tested and if there is considerable variation in the borrow pit, obtain a representative sample from each depth. Thoroughly dry a 6-lb. sample of the material in the oven. Usually 2 to 3 hours in a moderate oven will suffice but longer drying may be necessary if the sample is very wet. Pulverize the sample after it is dried and screen through a screen having a ⅛-in. mesh to remove coarse material. Weigh out exactly 5 lb. and add 4 fl. oz. of water and mix thoroughly. Using the small container place enough material in it to fill about one-third full when tamped. Experience gained after a few tests are run will enable the engineer to estimate the amount required for each layer.

Tamp the material that has been placed in the container with 25 blows struck lightly with the butt end of a claw hammer or a tamping stick of similar dimensions. Add enough material to fill the container two-thirds full when tamped and tamp as before. Fill the remaining third and tamp and as the last batch will tamp slightly be-

FIG. 1—WORK SHEET FOR SOIL DENSITY CURVES

SOIL TYPE—Sandy Loam. DEPTH—2'0" DATE—7-15-43

LOCATION

VOLUME OF CYLINDER—× 0.031 WEIGHT OF CYLINDER—0 25

Test No.	A Weight of sample	Gross weight	B Net weight	Oz. water added	C Weight of water	D Percent moisture	E Dry weight	F Wet density	G Dry density
8	5-0	2.72	2.47	0	0	..	2.47	79.8	79.8
8	5-0	2.78	2.53	2¾	0.147	3.	2.46	81.8	79.4
8	5-0	3.02	2.77	7¾	0.484	9.7	2.53	89.5	81.6
8	5-0	3.30	3.05	10	0.625	12.5	2.71	98.6	87 5
8	5-0	3.68	3.43	12	0.750	15 0	2.98	110.5	96.3
8	5-0	4.10	3.85	14	0.875	17.5	3.28	124.2	105.7
8	5-0	4.03	3.78	16	1.000	20.0	3.11	122.0	102.0
8	5-0	4.00	3.75	18	1.125	22.5	3.06	121.0	99.0

A=Weight of sample tested.

B=Gross weight—weight of cylinder.

C=Weight of water added in pounds.

$D=\frac{C}{A}\times 100.$

$E=\frac{B}{100+D}\times 100.$

$F=\frac{B}{X}$ (Vol. of cyl.).

$G=\frac{E}{X}$

X=Weight of water to fill cylinder+62.5.

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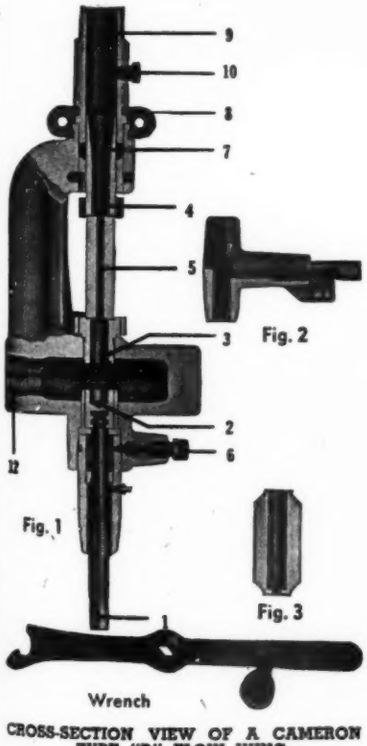
Note the absence of conventional wing valves in this Cameron 6,000 lb. test Safety Xmas Tree installed in the Stowell Field, Jefferson County, Texas.



CROSS-SECTION VIEW OF A CAMERON TYPE "D" FLOW WING

LIGHTER because the unique design of the Flow Wing combines all essential wing fittings in a single compact unit. Unlike conventional assembled wings, there are no heavy flanged connections between component parts of the flow wing, no choke nipples or choke housings, and the valve section of the unit obviates the need for conventional valves in the flow wing.

STRONGER because the Cameron Flow Wing is a one-piece steel casting whereas conventional wings consist of several fittings assembled with flanged or screwed connections.

MORE ECONOMICAL because it obviates the need for a conventional valve in the flow wing (eliminates two valves in double wing trees).

EASY TO OPERATE

Referring to Figure 1 at left, to change flow bean fit hexagon socket in wrench to valve stem (1) and close valve (2) against seat (3). Spanner part of wrench is then applied to clamp screw (4), and only two turns required to release flow bean (5). New bean is clamped in place by clamp screw and valve is then opened and well is back on production. Both valve stem and valve seat are faced with hard metal to resist cutting. Valve stem and bonnet are packed with plastic packing which may be replenished under pressure. Clamp screw is packed with an asbestos ring (7) which is tightened automatically as flow bean is clamped in place. Two-bolt union (8) obviates need for additional union in flow line. Note that downstream end of clamp screw is belled to reduce turbulence and cutting. Three types of flow beans are interchangeable: (1) "Proration" bean illustrated in flow wing; (2) adjustable flow bean, Figure 2; and (3) "production" type bean which consists of a body and renewable stellite orifice disc, Figure 3. All flow beans clamp in position as shown in Figure 1.

Cameron Flow Wings are offered in several screwed and flanged styles, ranging up to 10,000 lb. test. Like any standard fitting or valve, they may be incorporated in any manufacturer's Xmas tree.

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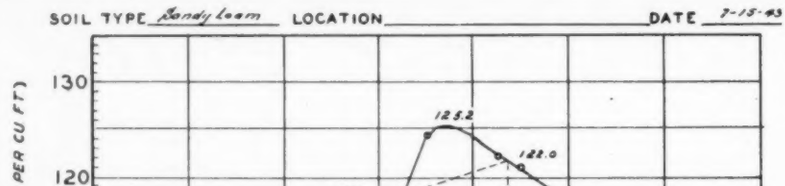

Fig. 2. Soil density control curve showing results of data from Fig. 1, and optimum moisture ranges

low the top of the container add enough material to more than fill the container and tamp lightly.

It should be borne in mind that it is the purpose of this procedure to obtain a degree of compaction as nearly similar as possible to that which will be obtained in the field when the fill or embankment is built. It is important to tamp each test in exactly the same manner although the exact routine may vary with the individual operator. After the material is tamped strike off the surplus even with the top of the container and weigh, recording the weight on the work sheet (Fig. 1.).

Return the material from the container to the mixing pan and add 2 oz. of water, mix and proceed as in the previous test. Continue this procedure until, as shown in Fig. 1, the maximum density point is reached and at least two points beyond the maximum density have been determined.

Compute wet and dry densities thus:

The weight per cu. ft. of the compacted material will of course be proportional to the ratio of the weight of the material to the volume of the container.

$$\frac{V_1}{V_2} = \frac{W_1}{W_2}$$

where:

V_1 = volume of container,
V_2 = 1 cu. ft.,
W_1 = weight of compacted material, and
W_2 = weight per cu. ft. or density.

Solving this equation for W_2,

$$W_2 = \frac{W_1}{V_1}$$

The volume of any container may be determined by weighing the empty container and then weighing the container when it is full of water. The volume then is proportional to the ratio of the weight of the water in the container to 62.5, the weight of 1 cu. ft. of water.

The dry density is found in a similar manner by dividing the weight of the dry material in the cylinder by the volume. The dry weight of the material is obtained by dividing the wet weight by 100 plus the percent moisture and multiplying by 100.

$$\text{Dry weight} = \frac{\text{wet weight}}{\text{percent moisture} + 100} \times 100.$$

The moisture percentage is found by dividing the weight of moisture added (see Table 1) by the weight of the sample and multiplying the result by 100.

By using a 16-oz. graduated container for the water and adding and measuring from this container each increment of water any error made in measuring the 2-oz. increments will be compensated when the next amount is added.

Fig. 1 is a form showing the results of a typical test.

From the densities obtained as shown in Fig. 1 prepare a control curve for this soil type as shown in Fig. 2. From this curve it is evident that the optimum dry density for this soil sample is 106.5. It is customary to assume that a density of 95 percent of the optimum will be satisfactory in most cases. Drawing a horizontal line at 101.2, 95 percent of 106.5, we find that this line intersects the curve at 16.2 and 21.5. Any moisture content between these limits should then allow compaction of the desired amount. Projecting these points to the wet density curve we obtain the weights that will afford a means of checking the density in the field.

Field Tests

The procedure for testing the completed fill or embankment is similar to that used in preparing the control curve but is less complicated. Fig. 3 is a form suggested for recording the results of the field tests.

Apparatus: 1 spring scale, reading in lb. and tenths and having a capacity

FIG. 3—WORK SHEET FOR SOIL COMPACTION TESTS

PROJECT_____ LOCATION_____

WEIGHT OF SOIL CONTAINER W 3.40

Date	Sample No.	Soil type	Gross weight, soil and container	A Weight of soil	B percent moisture	C Weight of dry soil	D Weight of sand, per cu. ft.	Weight of sand and container		E Weight of sand used	F Wet density	G Dry density
								Initial	Final			
7-16	123	No. 3	15.40	12.10	8.5	11.15	96.55	11.30	2.10	9.20	127	116

A=Gross weight—weight of container.

$B = \frac{\text{Weight of moisture}}{\text{Dry weight of sample}}$

$C = \frac{A}{100+B} \times 100$

$D = \frac{\text{Net weight of sand}}{\text{Volume of container}}$

E=Initial weight—final weight.

$F = \frac{A \times D}{E}$

$G = \frac{C \times D}{E}$

Inspector_____

The Responsibility of Leadership

Since 1932 Lane-Wells Company has been developing the technique of Gun Perforating and its application to the production of crude oil. Here, briefly, are some of the advancements pioneered and perfected by Lane-Wells Company in close co-operation with Oil Company operators and engineers:

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OGIVAL POINT GUN PERFORATOR **BULLET**

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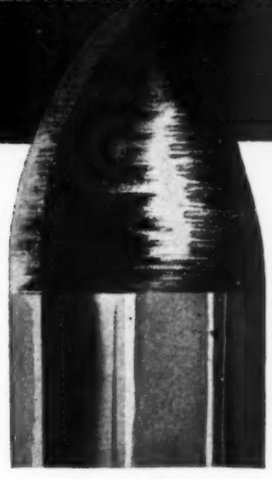

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All of these advantages Lane-Wells is able to deliver when we perform your gun perforating service work.

For complete details and the story of "Steelflo" Bullets and what they mean to you, call your nearest Lane-Wells Branch.

FIGHTING Tomorrow's Tools-Today!

LANE WELLS COMPANY

FACTORY, GENERAL AND EXPORT OFFICES
5610 SOUTH SOTO STREET, LOS ANGELES
HOUSTON . . . . OKLAHOMA CITY
30 BRANCHES • 24-HOUR SERVICE

LOOK TO LANE-WELLS FOR PROGRESS IN GUN PERFORATING

of 30 lb.; 1 short handled square point shovel; 1 earth auger, 4 or 6 in. diam.; 1 small sprinkling can with spout removed, 1 gal.; 1 bucket for containing sample; 6 1-pt. fruit jars with screw lids, and 25 lb. clean, dry, calibrated sand. (The sand is calibrated by determining its weight per cu. ft. This is done by pouring the sand from the sprinkling can with the spout removed into the 1/10 cu. ft. container. The container is then weighed, level full, and the weight of the sand per cu. ft. is found by dividing weight of the sand by volume of the container in cu. ft.)

Method: Obtain a 12-lb. sample from the fill or embankment to be tested by first removing 6 to 12 in. of the loose top soil and then smoothing off a space about 2 ft. square. A hole is then bored with the earth auger carefully saving all the dirt taken from the hole. Weigh the dirt recovered and compute weight in column "A". Fill the sprinkling can with sand and weigh, record weight in column marked "initial". Pour sand into the hole from which the earth was removed using just enough sand to replace the material removed and pouring in the same manner used when the sand was calibrated. Weigh the container and sand remaining in it and record in column marked "final". The difference between the initial and final weights is the amount of sand used, "E".

As the weight of sand used is proportional to the volume of the hole and the density of the soil is proportional to the ratio of the weight of the soil to this same volume we combine these equations and determine the wet density per cu. ft. by multiplying the weight of the sand per cu. ft. by the weight of the soil removed and dividing the result by the weight of the sand required to fill the hole:

$$\frac{A \times D}{E} = \text{density per cu. ft.}$$

The moisture content of the sample is determined in the laboratory by saving a sample of the soil tested in one of the small fruit jars. A portion of this sample is weighed out (150 g.) and then dried in an oven. The difference between the wet and dry weights is the weight of the moisture and the percentage of moisture is obtained by dividing the weight of the moisture by the dry weight of the sample and multiplying the result by 100:

$$\text{Percent moisture} = \frac{\text{Weight of moisture}}{\text{Dry weight of sample}} \times 100.$$

The dry weight of the test sample of soil is computed as before by dividing the wet weight of the sample by the percent of moisture plus 100 and multiplying the result by 100.

The dry density of the fill or embankment material is then equal to the product of the weight per cu. ft. of the sand by the dry weight of the soil excavated divided by the weight of the sand used:

$$\frac{C \times D}{E} = \text{Dry density per cu. ft.}$$

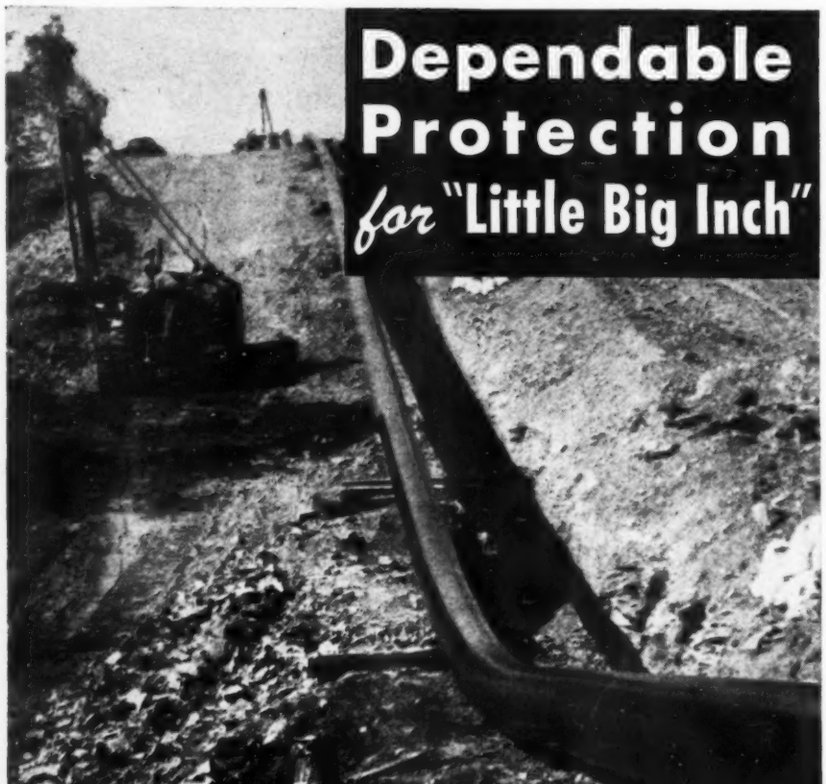
By comparing the results of the field test with the control curve for the type of soil used it can be determined whether the embankment has been adequately compacted.

Construction

The degree of compaction that can be obtained from a given soil is determined by two factors: The amount of moisture in the material that is placed in the embankment and the manner in which the embankment is built.

In practice it has been found practical to add the water, when needed, either to the borrow pit or to the grade as it is built. Water may be added either with a sprinkling cart or by sprinkling with a hose if a water connection is available. Sometimes when large embankments are built the borrow pit is puddled; that is, small dykes are built to hold the water and these small ponds are flooded until the required amount of moisture is absorbed by the soil.

Increments of dirt should be added to



with *Reilly* PIPE ENAMEL

Reilly COAL TAR PRODUCTS

17 PLANTS to Serve the Nation

● The many miles of "Little Big Inch" that are coated with Reilly Enamel are dependably protected. The Reilly coating prevents corrosion from moisture, electrolysis, soil acids or alkalies; resists abrasion and soil stress, and withstands extremes of heat and cold without sagging or cracking . . . Reilly cold application coatings give dependable, economical protection to storage tanks, structural steel work and other exposed metal . . . Booklet describing Reilly Protective Coatings will be sent on request.

REILLY TAR & CHEMICAL CORPORATION

Executive Offices: Merchants Bank Building, Indianapolis, Indiana

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SEVENTEEN · PLANTS · TO · SERVE · YOU

A
COMPLETE LINE OF PUMPS
for Every Type of Operating Condition

Regardless of well depth, fluid level, sand and corrosion conditions, surface equipment, etc., we manufacture a pump to efficiently and economically solve your pumping problems.

"GROOVE SEAL" An economically priced pump providing 4 to 8 times harder barrels than ordinary pumps. Longer production and fewer replacement parts make these "Groove Seals" today's outstanding value. These pumps are equipped with hardened and honed barrels and grooved plungers, in either the one-piece chrome plated or the composite sleeve type.

"VOLUME PRODUCER"

Designed to give the largest practical cross-sectional displacement area of any insert (rod) type pump. Easily handles deeper wells of normal volume.

Assembly Designs:

Traveling Barrel, Bottom Anchor—Rod Type
Stationary Barrel, Bottom Anchor—Rod Type
Stationary Barrel, Top Anchor—Rod Type

"PRODUCER"

This pump meets the needs for producing wells of medium depth and volume. Both initial and maintenance costs are low enough to warrant "Producer" pump installations in any "stripper" well.

Assembly Designs:

Traveling Barrel, Bottom Anchor—Rod Type
Stationary Barrel, Top Anchor—Rod Type

"VICTORY"

The "Victory" pump with its Hardened and Honed Barrel and One-Piece Chrome Plated Plunger is designed to meet the toughest of pumping conditions encountered in the small bore (1¼") installations. It is available in 7', 9' and 12' lengths with 24", 36" or 48" plungers. Competitive in price with pumps having untreated barrels but equal to the best in quality and performance.

Assembly Designs:

Stationary Barrel, Bottom Anchor—Rod Type
Stationary Barrel, Top Anchor—Rod Type

"PETROL-A"

The popular "small production" installation. This 1-1/16" bore pump has been advanced from the shallow well type pump until now the line includes hard metal pumps for deep wells making "stripper" production. Ideally suited to jack-line or small pump unit operation. It is a real low cost hard metal pump. Lightens the load and reduces cost.

Assembly Designs:

Stationary Barrel, Bottom Anchor—Rod Type
Stationary Barrel, Top Anchor—Rod Type

"IMPROVED INSERT"

The quality pump of solid one-piece barrel construction. Hardened and honed walls of extra thickness assure unusually long life and permit several rehone jobs. The most versatile hard metal pump available.

Assembly Designs:

Traveling Barrel, Bottom Anchor—Rod Type
Stationary Barrel, Top Anchor—Rod Type

"FLUCUP"

A cup and barrel type pump of improved construction with hardened and polished barrel. Highly satisfactory for "easy to pump" wells and also recommended for wells making high gravity oil with poor lubricating qualities.

Assembly Designs:

Traveling Barrel, Bottom Anchor—Rod Type
Stationary Barrel, Top Anchor—Rod Type
Stationary Barrel, Bottom Anchor—Rod Type

"FLU-RING"

Combines a number of composition rings on a plunger body for effective sealing. One of the most efficient types for pumping wells where water volume or lubrication-free fluid is a problem.

Assembly Designs:

Traveling Barrel, Bottom Anchor—Rod Type
Stationary Barrel, Bottom Anchor—Rod Type
Stationary Barrel, Top Anchor—Rod Type

"FLUID PACKED" (Three tube type)

This is the "all-purpose" pump and is especially adapted for troublesome wells where excessive sand or shale conditions prevail. The "fluid being pumped" acts as a sealing factor between the properly spaced tubes. This pump is known to economically produce wells which heretofore were unprofitable to operate or impossible to pump with conventional type pumps. It is also highly recommended for all types of pumping conditions and will provide for a long life service in normal or abnormal conditions.

Assembly Designs:

"Positive Pull" Type, Bottom Anchor—Rod Type
"Removable" (Key) Type, Bottom Anchor—Rod Type
"Marginal" Positive Pull Type, Bottom Anchor—Rod Type (Short Type for Shallow Wells)

"TUBING LINER PUMP"—Tubing Type

These pumps are of the standard tubing liner type. The "Service" liners being encased within a jacket with Top Collars both ends and Extension Shoe and Nipple. The standing valve can be run in on the bottom of the plunger and is easily disengaged from the plunger when seating it in the shoe. The automatic hook-on device makes it easy to engage again when it is necessary to pull the standing valve body.

This quality tubing type pump is recommended for hard service wherever a tubing pump is required equipment.

"T-V" Rigid One-Piece TUBING LINER BARREL PUMP—Tubing Type

This special pump has the same features as the regular tubing liner pump except that the One-Piece Hardened and Honed Barrel requires no jacket.

FLUID PACKED PUMP CO.

MAIN PLANT: LOS NIETOS, CALIF.

HUNT BLDG., TULSA, OKLA.; 6006 NAVIGATION BLVD., HOUSTON, TEXAS; TEXAS BK. BLDG., DALLAS, TEXAS; NAT'L SUP. CO. STORES, ILLINOIS FIELDS

World's Largest Exclusive Oil Well Pump Manufacturers

the fill or grade in thin (4 in. to 8 in.) layers and each layer should be sprinkled and rolled or compacted in some manner before another layer is added. In the field compaction is obtained either by rolling with a sheep's foot roller if one is available or by making the required number of passes with a caterpillar tractor or other heavy machine. Weighted pneumatic tired rollers may be used.

Tests are usually taken in the layer of material below the last one placed.

An engineer engaged in the supervision of dirt work will soon be able to judge the percentage of moisture by the feel of the dirt and by taking tests where he suspects inadequate compaction he will be able to maintain control over the operation that will result in the completion of a grade with the stability consistent with the requirements and purposes it is to fulfill.

By exercising such control fills can be built that will not settle when wet and that will have a bearing capacity and stability equal to or above that of undisturbed ground.

Choice of Materials

When a variety of materials are available the best material should be selected and used. Loose materials or poorly sorted lumpy material should be rejected as they will require greater amounts of rolling before adequate compaction can be obtained. If the available material is "clayey" or sticky, sand can be added to obtain the necessary stability. When loose rock is used in making a fill special care should be used to assure that the voids around and between the rock are filled with fine material. If this is not done percolating waters will later wash material into these voids and cause uneven settling and holes to result in the finished grade. Rock in a fill will increase its resistance to shear if properly placed but if it is intended that the embankment is to contain or obstruct the movement of liquids special care should be exercised to see that there are no voids left in the fill.

The engineer in charge of the work should keep notes on the location and conditions existing where the soil tests are taken and also of the tests that are taken in the finished grade or fill.

It is also advisable to prepare forms similar to those illustrated for recording the data of the sand calibration tests and for recording the moisture tests. Columns should be provided for recording the gross and tare weights and the net weights of the materials tested and for the weight per cu. ft. of the sand tested and the moisture content of the soils checked. These forms may be hand ruled or mimeographed, according to the number of tests.

TABLE I

Conversion table for oz., lb. and grams of water

Oz.	Lb.	Grams
¼	0.0156	7.09
½	0.0313	14.2
¾	0.0469	21.3
1	0.0625	28.4
2	0.125	56.7
3	0.188	85.0
4	0.250	113.0
5	0.313	142.0
6	0.375	170.0
7	0.438	199.0
8	0.500	227.0
9	0.563	255.0
10	0.625	284.0
11	0.688	312.0
12	0.750	340.0
13	0.813	369.0
14	0.875	397.0
15	0.938	425.0
16	1.000	454.0

The following remarks were made by Irving B. Crosby, geologist, at the opening of the Boston Conference: "... All soil mechanics studies and laboratory investigations of foundation problems of whatever kind are applied to geological formations and structures. Unless those formations and structures are correctly understood the most accurate laboratory work will be misleading.... Closer cooperation between specialists in soil mechanics and geologists who have specialized in foundation problems will be of great advantage to both sciences." ——— ☆ ☆ ☆ ———

RUBBER PRODUCTS

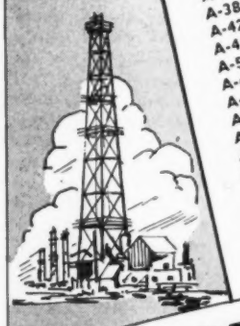
AVAILABLE IN STOCK

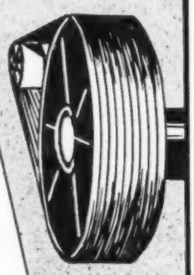
V-BELTS

MULTIPLE DRIVE BELTS — MATCHED SETS

PARTIAL LIST OF SIZES

Belt Sizes A WIDTH	Belt Sizes B WIDTH	Belt Sizes C WIDTH	Belt Sizes D WIDTH
A-26	B-42	C-51	D-120
A-31	B-46	C-60	D-128
A-35	B-51	C-68	D-144
A-38	B-55	C-75	D-158
A-42	B-60	C-81	D-162
A-46	B-68	C-85	D-173
A-51	B-75	C-90	D-180
A-60	B-81	C-96	D-195
A-68	B-85	C-105	D-210
A-75	B-90	C-112	D-240
A-80	B-97	C-120	D-270
A-85	B-105	C-128	D-300
A-90	B-112	C-144	D-330
A-96	B-120	C-158	D-360
A-105	B-128	C-162	E WIDTH
A-112	B-144	C-173	E-180
A-120	B-158	C-180	E-195
A-128	B-173	C-195	E-210
	B-180	C-210	E-240
	B-195	C-240	E-270
	B-210	C-270	E-300
	B-240	C-300	E-330
	B-270	C-330	E-360
	B-300	C-360	





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A.P.I. SPECIFICATIONS

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Width Ply	Width Ply
8" x 6	14" x 6
10" x 6	16" x 6
12" x 6	18" x 6

(Other Sizes Available)

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LOADING RACK, OXY-ACETYLENE WELDING, COMPRESSORS, STEAM, OIL, SUCTION, WATER, FIRE, PAINT, ETC.

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see page 576 Composite Catalogue

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Merry Christmas

More than 250 members of the Hunt Tool Company office, shop and field staffs take this means of extending the Season's Greetings to their thousands of friends throughout the oil fields of the world.

HUNT TOOL COMPANY

STOODY 6
Applied by Welding Reclaims Worn Valves

NOW worn valves, valve parts and pump sleeves can be reconditioned to outperform new factory parts by a simple oxyacetylene welding application using Stoody 6. This new Stoody alloy, composed principally of cobalt, chromium and tungsten, will not oxidize—even under intense heat, has high impact strength in relation to its hardness, offers excellent resistance to abrasive wear, and is perhaps the easiest of all hard-facing alloys to apply. Stoody 6 is highly efficient for hard-facing new or old internal combustion exhaust valves, gate, globe and angle valves, hot oil pump sleeves, etc.

Trial order of 10 lbs. of 3/16" diameter Stoody 6 at $4.25 per lb. will prove the merits of this alloy for any applications involving heat, corrosion, abrasion and impact. Available on AA-4 or higher priority rating.

STOODY COMPANY
1142 West Slauson Ave., Whittier, Calif.

STOODY HARD-FACING ALLOYS
Stop wear . . . Eliminate Repair

LAUGH WITH BARNEY

If You Must Drink . . . .

For the married man that absolutely must drink: Start a saloon in your own home. Be your only customer and you won't have to buy a license. Give your wife $9.00* to buy a gallon of whiskey. Remember, there are 69 glasses in a gallon. Buy your drink only from your wife. When the first gallon is gone, she will have $8.00 to deposit in the bank and $9.00 to start business again. If you should live ten years and continue to buy booze from her and then die with snakes in your shoes, she will have enough to bury you respectfully, bring up your children, buy a house and lot, marry a decent man and forget all about you.

---

* ? ?

* * *

"What pretty hair you have, Jean. You get it from your mother, don't you?"

"No, I s'pose I get it from daddy. His is all gone."

* * *

Heaven protects the working girl
But heaven I fear is shirking.
For who protects, I'd like to know,
The fellow she is working?

* * *

Shapely Showgirl: I want you to vaccinate me where it won't show.

Doctor: Okay. My fee is ten dollars in advance.

Showgirl: Why in advance.

Doctor: Because I often weaken in such cases and don't charge anything!

* * *

General MacArthur has, it seems, his lighter moments. One of his favorite yarns is that of a child who asked his father the difference between a Garand repeating rifle, and an ordinary gun. "Well, it's like this," replied the Dad. "It's just as if I spoke, and then your mother spoke."

* * *

Recycling on the Farm

A city lassie, working on a farm during her vacation to help out with the labor shortage, was observed by her farmer employer doing a very odd thing. She was allowing the cow to drink a pail of milk she had just obtained from the animal.

"What's going on here?" stormed the farmer. "Why are you letting the cow drink all the milk?"

"Well," replied the farmerette, "the milk looked pretty thin and I thought it might help to run it through again."

* * *

Definition of a wolf: A fellow who takes a sweater girl out just so he can pull the wool over her eyes.

* * *

Did you hear about the man from the Bronx who was wandering in the Libyan desert dressed in a bathing suit? He finally ran into an Arab, who blinked in amazement. "Why the bathing suit?" he asked.

"I am going to take a swim in the ocean," said the Bronxite.

"Swim in the ocean? Why the water's 800 miles from here."

The Bronx gent whistled in awe. "800 miles? Say, is this a beach!"

* * *

"Well, I guess I might as well put the motion before the house," thought the chorus girl as she danced out on the stage.

* * *

"Do you believe that tight clothes stop circulation?"

"Not with a woman. The tighter the clothes the more she's in circulation."

* * *

Brooklyn, although it is one of the United Nations, continues to speak a foreign language.

For instance, the other day a young Brooklyn boy went to visit his aunt in the country. Suddenly he cried out:—"Look, Auntie Moytle—a boid!"

Auntie Moytle replied: —"That's a bird, dear—not a boid!"

"Well," he said, "it choips like a boid!"

* * *

Gentleman in His Cups (to gentleman in next seat): "Shay, was that las' tushdown made during the second or third quart'?"

* * *

Fortune Teller (*to Hitler*)—"You will die on a Jewish holiday!"

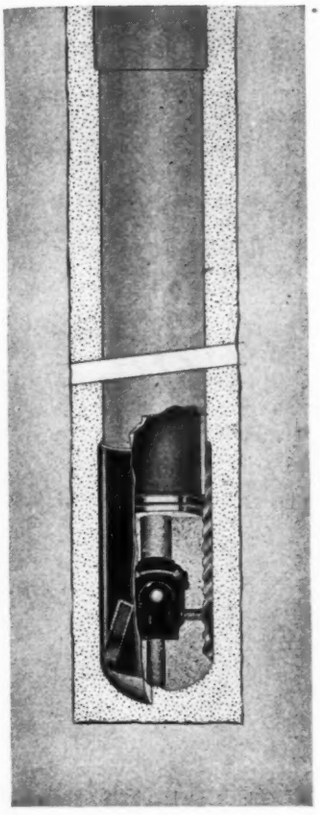
"Why on a Jewish holiday?"

"Whatever day you die will be a Jewish holiday!"

* * *

Private Flinch was late for parade. "Well, it's nice to see you, soldier," said the Sergeant in a well-modulated snarl. "We had so feared you had signed a separate peace."

Here is Why Whirler Action is So Important Today in Washing Formation, Removing Bridges, and Cementing



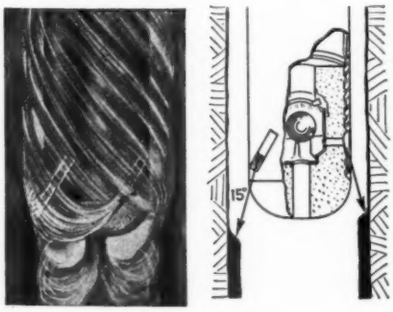
Under today's conditions, the securing of a successful first-time cement job is more than just "important" . . . ***it is vital!*** We can't afford to lose the additional man hours, rig time and materials required for a "second-time" job. They are needed to drill and cement a second well—not for second-time use on the same well.

Baker's contribution to this war-time problem, is making available cementing devices which afford every possible opportunity for securing successful results the ***first time.***

An outstanding example of such a device is the *Baker Cement Wash-Down Whirler Float Shoe (usually used in combination with a Baker Cement Float Collar). This Shoe not only assures safe and proper landing of the casing, but through its efficient "whirler action" provides best possible chance for complete encasement of the pipe with a uniform body of cement, with the hazard of channeling reduced to a minimum. In addition, when the cement job is completed, the internal construction of the Baker Cement Wash-Down Whirler Float Shoe can quickly and easily be drilled out leaving no harmful fragments in the hole to interfere with further deepening operations.

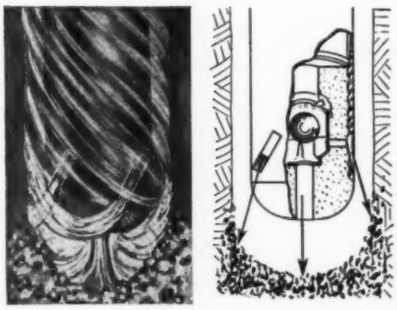
Field results have indicated that the whirler action afforded by Baker Cement Wash-Down Whirler Equipment is both effective and advantageous in washing formation, removing bridges and particularly in securing a better cementing job. ★ The whirling motion imparted to the fluid as it leaves the Shoe, is the basic reason for the unit's remarkable effectiveness. Another contributing factor is the slight angle from the vertical at which the fluid leaves the ports (there is no direct jetting action against the side walls of the hole). ★ The results operators are securing in landing and cementing casing with Baker Cement Wash-Down Whirler Equipment bears out the soundness of the engineering principles incorporated in these units. The illustrative sketches below (not drawn to scale) show these principles in operation.

WASHING FORMATION



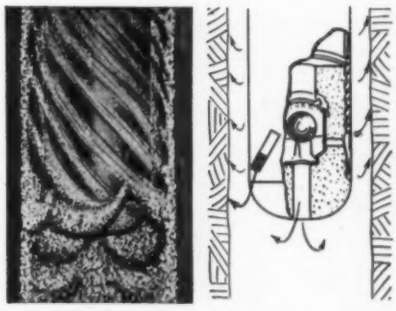
Note that the fluid is discharged through the baffled whirler ports at a slight angle from vertical (approximately 15°), effectively washing and removing at least a portion of the mud cake. There is no direct lateral jetting action against the side walls of the hole.

REMOVING BRIDGES



The angle of discharge through the baffled whirler ports of the Shoe directs the fluid against the ***sides of the bridge.*** The fluid which is discharged through the bottom of the Shoe also simultaneously attacks the center of bridge.

CEMENTING RESULTS



Uniform cement distribution is provided by effective whirling action imparted to fluid as it leaves the Shoe. Scouring action of the fluid preceding the cement, as well as scouring action of the first slurry as it strikes the formation, cleans the walls and affords best possible bond between the cement and formation at critical point—the Shoe and the Shoe joint.

Service Note
Competent Baker men will advise, make suggestions, and otherwise assist in securing best possible results.

BAKER OIL TOOLS, INC.

Main Office and Factory:
6000 So. Boyle Ave., Box 127, Vernon Station, Los Angeles, Calif.

Central Division Office and Factory:
6023 Navigation Blvd., Box 3048, Houston, Texas

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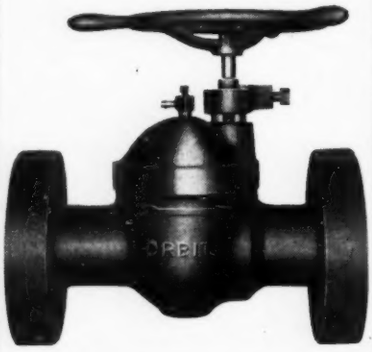
Awarded to Los Angeles Plant—1943

BAKER OIL TOOLS INC. BAKER SERVING THE WORLD

ORBIT VALVES

The Valves that can "Take It"



ORBIT MASTER VALVE

The Orbit Master Valve is quick opening—has easy operation and a positive shutoff. A welded bonnet valve—insurance against possible gasket leaks.

YOUR ORBIT VALVES

will last for the duration. Meanwhile, if you have any questions regarding their care or maintenance, write us.

OIL WELL IMPROVEMENTS CO.

Since 1912

TULSA, OKLAHOMA

Running Tour

WITH MEN IN THE INDUSTRY

JOHN W. CARNES, vice president and general manager in charge of sales for Sinclair Refining Company, a member of the Petroleum Industry War Council, and chairman of the marketing committee of District 1, PAW, died in a New York hospital November 20 of double pneumonia following a major operation. Carnes had been associated with Sinclair for more than 25 years.

DR. ALOIS CIBULKA is head of a new concern, "RST" Engineering Company, organized for consulting, structural and industrial engineering. Offices are at Highlands, Texas, and 712 Sterling Building, Houston, Texas. "RST" represents "reinforced steel timeber" a patented design in structure method that is owned solely by the new company.

P. O. TETER of Bartlesville, Oklahoma, has been named general superintendent of the Oil Pipeline and Storage Division of Cities Service Oil Company. He succeeds HARRY NELSON who was promoted to the position of acting division manager. Teter joined Cities Service in 1923 as a junior engineer and has steadily advanced since.

WILLIAM M. AVERILL, Corpus Christi, Texas, was appointed director of District 3 (Southwest) of Petroleum Administration for War to succeed D. E. Buchanan, who resigned to return to his post as vice president of Hanlon Buchanan, Inc., Tulsa, Oklahoma. Averill has had more than 35 years experience in the oil business.

C. W. THORNWAITE, former geography professor at the University of Oklahoma, has been made chief of the Bureau of Soil Conservation Service, Washington, D. C.

E. ROY SHAW, former regional personnel manager in the eastern division, Carter Oil Company, has been transferred from St. Elmo, Illinois, to Tulsa, Oklahoma, where he succeeds ALBERT T. WISNER as assistant personnel manager. Wisner recently volunteered for the merchant marine.

H. C. (JERRY) JEROME, former personnel manager in the central division, Seminole, Oklahoma, will replace Shaw in Illinois. NOBLE F. JONES, former chief clerk to Bruce Ramsey, vice president of the Oklahoma Pipe Line Company, succeeds Jerome.

CARL LEE has been named general superintendent of the Texas-Gulf area of the Shell Oil Company, Inc. Lee has been with Shell for 26 years. RICHARD MYERS, who has been associated with Shell 15 years, is the new drilling superintendent in the area.

HENRY L. WILLIAMS, 73, pioneer in several oil fields in the West and north of the Arctic Circle, died November 19 at the home of a business partner, James W. England, Jr., at Tulsa, Oklahoma. Williams went to New Mexico in 1929 and became one of the state's largest independent operators.

C. E. ROBERTSON, superintendent of the refinery of Republic Oil Refining Company in Texas City, Texas, has retired, according to an announcement by E. L. SAUER, vice president. He is succeeded by C. C. EVANS, who has been assistant superintendent since 1933. RUSSELL HOMSTEN, process supervisor since 1939, has been named assistant superintendent in charge of operations, and LOUIS KELLER, plant engineer since 1934, is the new assistant superintendent in charge of engineering and maintenance.

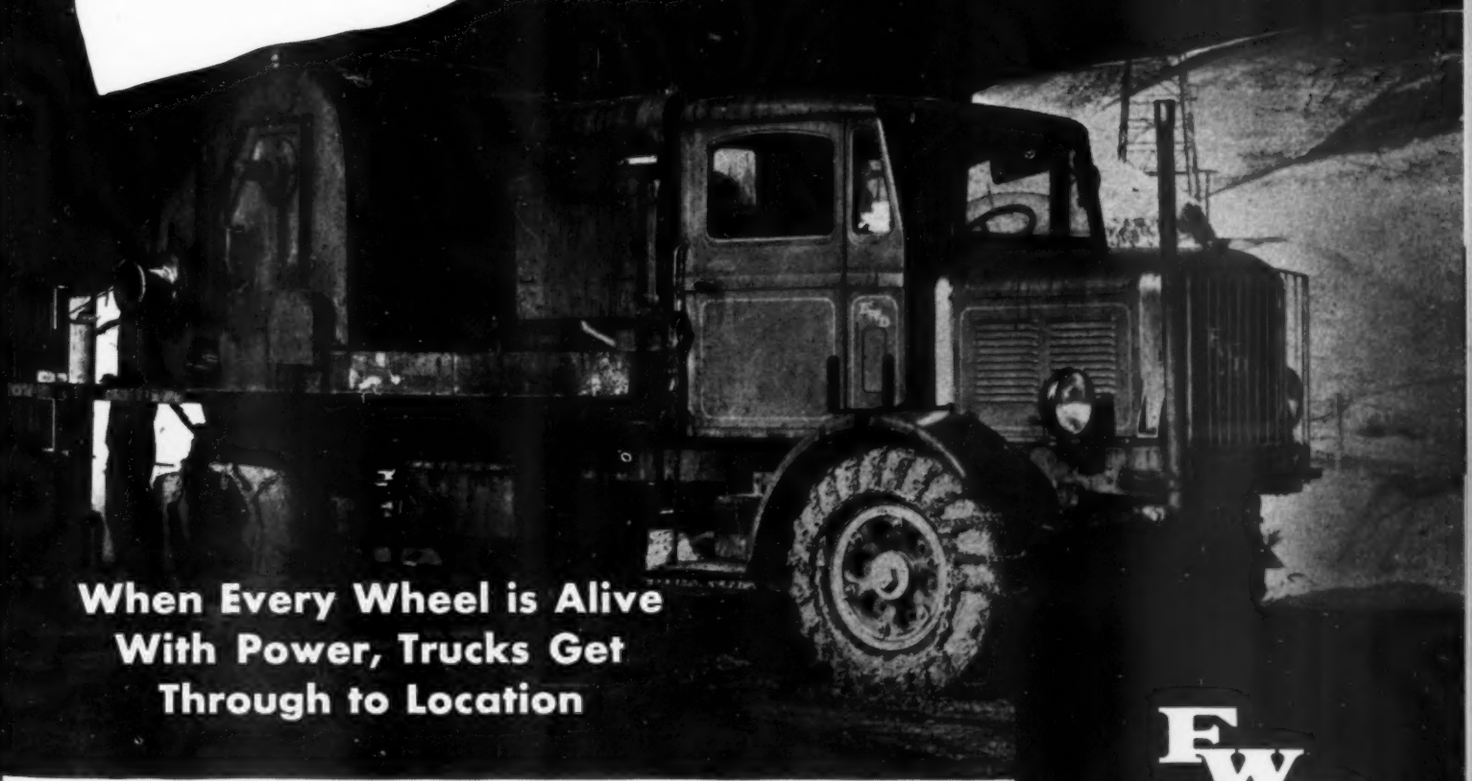
JUBAL R. PARTEN has resigned as director of transportation for the Petroleum Administration for War to return to the presidency of the Woodley Petroleum Company, Houston, Texas, and to the chairmanship of the board of the Premier Oil Refining Company, Longview, Texas.

GEORGE A. WILSON, on leave from Standard Oil Company of Louisiana, was appointed to succeed Parten. He was in charge of the law department for Standard at Shreveport, Louisiana, before he went with PAW in 1942 as assistant to Major Parten.

GAIL F. MOULTON has joined the department of petroleum economics of the Chase National Bank of New York to be in charge of the department's geological work. He has recently been engaged in oil production operations and consulting work at Lawrenceville, Illinois. Moulton left the Illinois Geological survey nearly 15 years ago and has served since with the United Gas Company in Houston, Texas, the Electric Bond and Share Company and Ralph E. Davis, Inc. in New York.

Hauling Power

THAT MEETS EVERY DEMAND FOR DIFFICULT OIL FIELD DUTY



When Every Wheel is Alive With Power, Trucks Get Through to Location

Oil-field operators depend on FWD four or six-wheel drive trucks to "get there" with men and gear, regardless of weather or road conditions.

When every wheel is alive with power, every ounce of truck and load is converted into powered traction. Power on all four wheels results in unbelievable performance — when one axle fails to find traction, other axles will — you're sure to get to location. And, more important than ever today, the true application of the four-wheel-drive principle in FWD's — holds operating and maintenance costs — gas, oil, tires, replacements — to very minimum.

Write for literature giving complete information on FWD four and six-wheel drive trucks for every oil-field hauling requirement.

THE FOUR WHEEL DRIVE AUTO CO.
Clintonville, Wisconsin
Canadian Factory: Kitchener, Ontario
(The Oldest and Original Exclusive Builders of Four-Wheel-Drive Trucks)

FWD
TRUCKS

IN EVERY FIELD WHERE TRUCK QUALITY IS PUT TO THE TEST... FWD's STAND UP

MACHINERY and EQUIPMENT

Le Roi Engine

LE ROI COMPANY has announced a new 4-cylinder, valve-in-head engine. It is the Model D140, the result of a background of long experience in the design and construction of heavy duty engines.

It is the newest addition to the comprehensive line of durable and dependable Le Roi engines. Other Le Roi units range from 2 to 12 cylinders, and 4 to 400 hp.

The new engine has a piston displacement of 140 cu. in. and develops up to

33 hp. at 2400 r.p.m. Embodied in the D140 are features typical of those incorporated in other Le Roi engines—rugged construction, accessibility, and simplicity of design. All combine to make a heavy duty engine that is economical to operate, easy to maintain, and designed for continuous service and long life, the manufacturer states.

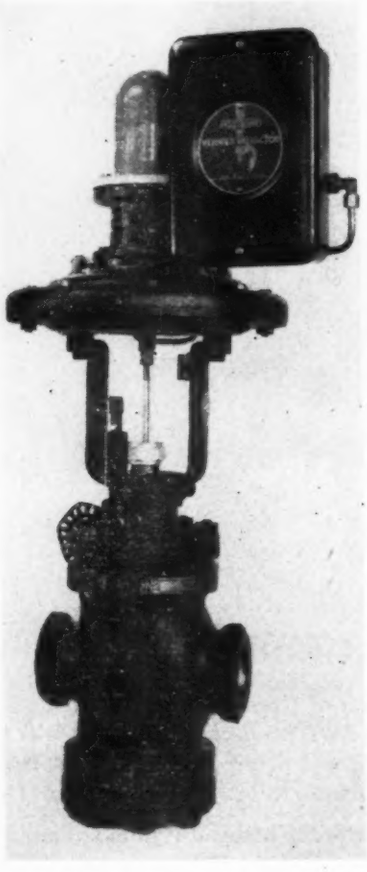
The valve-in-head arrangement and wet cylinder sleeves are two of the more important features. They combine to make the D140 efficient to operate and inexpensive to maintain.

A drop forged, counterweighted crankshaft, extra large main bearings, vertical magneto, drop forged connecting rods, precision bearings, oil bath air cleaner, valve seat inserts, full pressure lubrication, and conveniently placed controls combine with other Le Roi features to produce an engine that can be utilized for a great variety of applications.

A more complete description may be obtained by writing Le Roi Company, 1706 South 68th Street, Milwaukee 14, Wisconsin, for a copy of Bulletin 140.

Foxboro Valvactor

NEW capabilities, as well as new convenience and sturdiness, are featured in a new vernier valvactor, announced by The Foxboro Company, Foxboro, Massachusetts. The Foxboro vernier valvactor, familiar to users of



A Foxboro Stabilflo valve equipped with the new vernier valvactor

control instruments in every field of industry, is a micro-positioner for pneumatic motor valves. It is used to insure precise and dependable valve response, especially where operating conditions may make the response uncertain, slow, or unsatisfactory. It is actuated by air pressure changes as slight as the equivalent of ½ in. of water, and can compel valve stem movements as small as 1/1000 of an inch.

Continuing the same operating principles that have made the vernier valvactor so successful in eight years of widespread use, the new construction involves a completely different arrangement of the actuating elements. New ease and range of adjustment, especially for duplexing and sequencing, and new snap action, for relay service or step sequencing of valves or damper motors, are provided by new, convenient zero and range adjustments. New ease of reversal is provided without change of parts or piping.

The new unit retains the outstanding advantage of relay action. Flexure type bearings, in place of pivots, eliminate the effect of mechanical vibration without loss of sensitivity. Finally, although the vernier valvactor retains the same general external appearance, new ruggedness has been provided for it by a heavier metal case. Complete specifications of the new type unit will be supplied by The Foxboro Company on request.

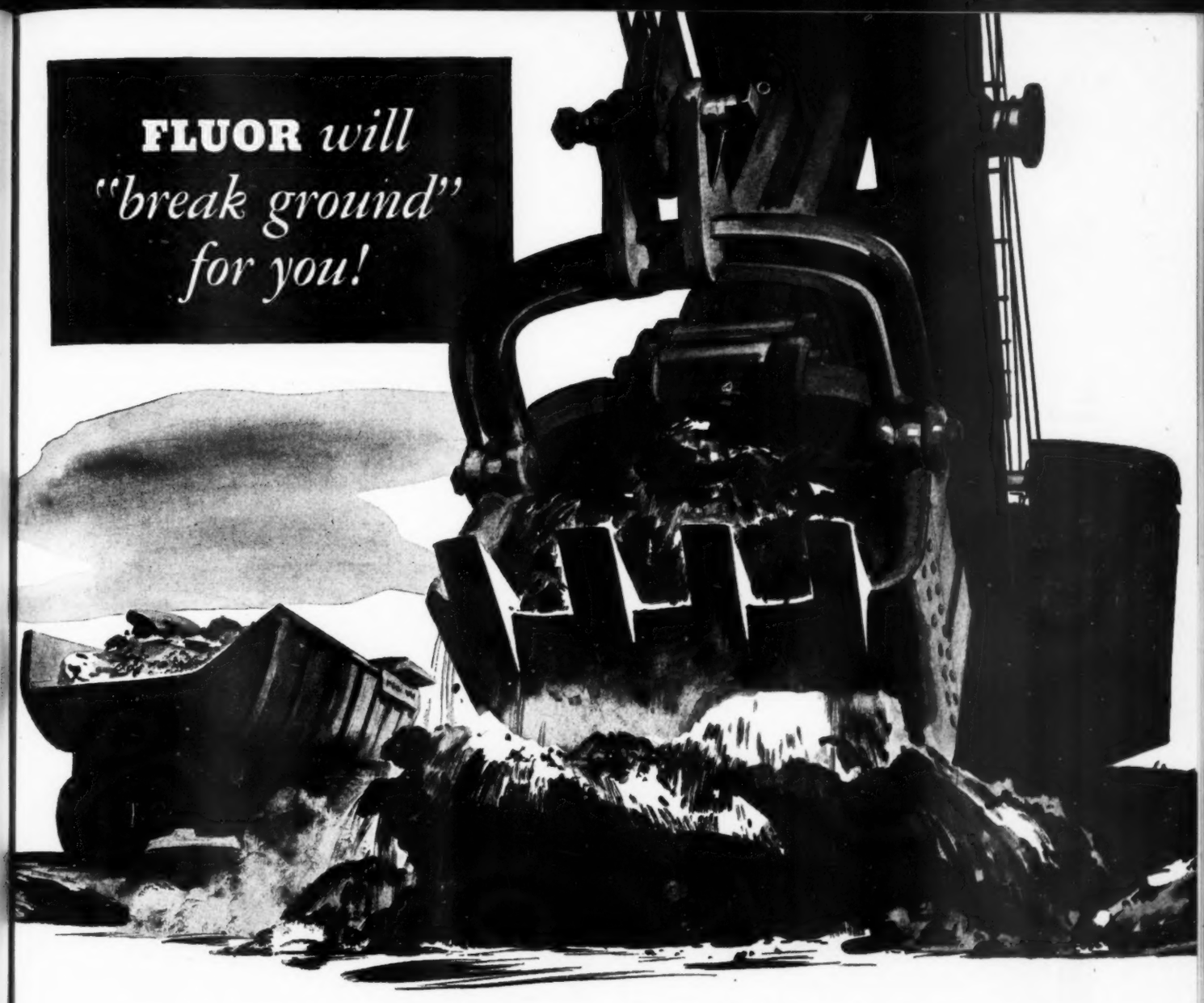
Fluorescent Luminaire

DESIGNED for easy continuous strip installation, a new lightweight fluorescent luminaire with one-piece, double-length hood and two full-size reflectors is announced by Westinghouse Electric and Manufacturing Company.

Available for use with four or six 40 watt or four 100 watt Mazda F lamps, the new Type F N C luminaire is the equivalent of two conventional units. The hood is fabricated from sheet steel with all ballasts, lamp holders, and starter sockets mounted and wired as part of the channel assembly. New sliding hangers permit suspension from any part of the hood. Mounting arrangements are available for any application.

The moisture-resistant, non-metallic reflectors are covered with a multi-coat polymerized finish that provides a reflection factor of 85 per cent or more. Wing-lock permits easy removal of reflectors for cleaning.

Further information may be obtained from the Westinghouse Lighting Division, Edgewater Park, Cleveland, Ohio.



THIS POWER SHOVEL is just *one* piece of equipment—that operator is just *one* man in Fluor's vast reservoir of equipment and men ready to break ground for you.

Maybe you need a complete refinery, or any one of these plants: catalytic cracking, alkylation, isomerization, toluene, natural gasoline, recycling, gas transmission or synthetic rubber.

Possibly it is a modernization of your present plant or plants that you need. Whatever your requirements are, consider these facts.

Fluor has an organization of 5,000 men—from engineers to laborers—trained and equipped to design, engineer and construct such plants *now*.

Fluor owns and maintains every piece of equipment necessary to handle any construction job—large or small. This equipment is spotted at key points throughout the United States ready for instant movement to your job.

Fluor has a record of more than half a century of successful construction for the oil, gas, and allied industries—a record built on the policy of always on time from *plan* to *plant*.

Fluor offers you these established facts, *plus speed* in the successful completion and operation of your new plant, or in the modernization of your present facilities.

Write or wire your nearest Fluor office today for an immediate discussion of your plant construction needs.

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SINCE 1909

Synchronous Motors

A NEW line of vertical high speed, hollow shaft synchronous motors has been announced by the Motor Division of the General Electric Company, Schenectady, New York. Supplied in ratings from 100 to 1000 hp., and in speeds from 514 to 1800 r.p.m., these motors are especially desirable for pumping applications where a large volume of fluid is handled, such as in ord-

nance and synthetic rubber plants, and on municipal and government water projects.

For protection, these motors have a dripproof enclosure. They are streamlined throughout to provide a pleasing appearance, and their smoothly contoured lines will not easily collect dirt and dust. The top cover of the motor is easily removed to permit adjustment of the pump shaft. In addition, easy access to the brushes and the collector rings is obtained by simply unlatching a flush-mounted steel plate.

The frames of these motors are of cast-iron construction, which provides strength to withstand the high thrust loads often encountered in pump applications.

The motors can be supplied with non-reverse ratchets to prevent reversal of pump rotation at shutdown or on starting. They are also available in solid-shaft construction.

New Synthetic Rubber

A NEW synthetic rubber, the sixth major type to be discovered through chemical research, has been developed by the General Laboratories of United States Rubber Company, it was announced by Herbert E. Smith, president.

"Known as uskol, this new synthetic will be used in both industrial and household products," Smith said. "As a result of its distinctive properties, it is expected to take its place alongside the present five commercial types of synthetic rubber—buna S, buna N, neoprene, butyl, and thiokol.

"Offering a new high degree of resistance to solvents, this new synthetic will be used in the manufacture of commodities that come into contact with fuels, oils, gasoline, dry cleaning fluids, and other penetrating chemicals that are the enemies not only of natural rubber but of the other five synthetic types. It will also be used for specialties such as industrial molded items, tubing, gas and oil hoses, tank linings, and for application to paper and cardboard to render them resistant to grease, water, and chemicals.

"Household goods such as mats, dish drainers, sink strainers, aprons, gloves and the like may be made from the new rubber. It also may make possible for the first time the manufacture of raincoats that can be dry cleaned."

In addition to its ability to resist solvents, uskol is said to possess numerous other features, including the following: it can be vulcanized in several ways to acquire high physical properties; it has high tear resistance exceeding that of natural rubber; it can be used alone or as a blend with other synthetics; it is resistant to the effects of sunlight, ozone, and oxygen; it has no odor either in the raw material state or in the finished product; it can be produced with present machinery, and it is easy to handle during manufacture.

This new synthetic will be made by the company's chemical division at Naugatuck, Connecticut.

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PUMPS
CINCINNATI, OHIO
McGOWAN
ENGINEERING
a
dependable service
McGowan Pumps are constructed for dependability and economy of operation. Our Engineers are constantly designing McGowan Centrifugal and Reciprocating Pumps to meet rapidly changing present day requirements. All castings are carefully checked by expert metallurgists. While we have attempted to design McGowan Pumps with the best features suiting the large majority of users, our engineering staff is always ready and willing to aid in solving your problems relative to installation and specific requirements.
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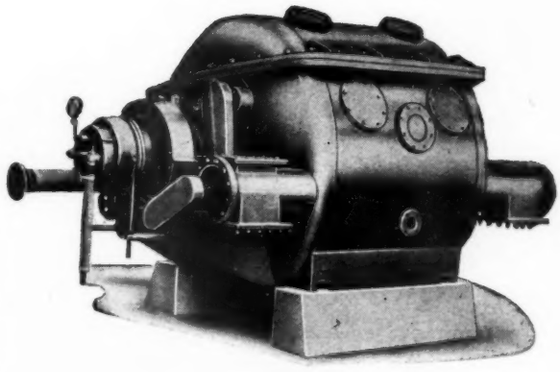
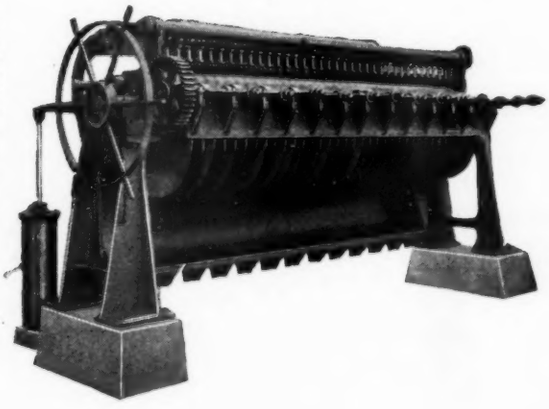
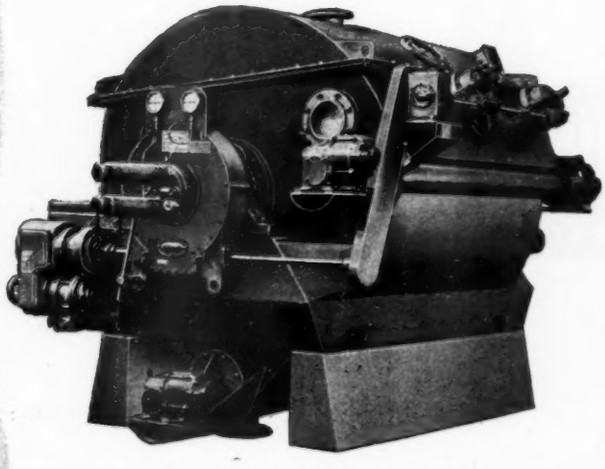
OUF

Specialists in PRESSURE *and* CONTINUOUS VACUUM FILTRATION







Add "Continuous Pressure Filtration" to the headline and you have a ten-word picture of the scope of filtration and clarification service offered by Oliver United engineers. From them you can obtain experienced advice on such problems and you can select from a wide variety of:

Batch Pressure Filters
Continuous Pressure Filters
Continuous Vacuum Filters

plus

The Oliver Precoat Method of Continuous Filtration which long ago proved itself best for handling certain materials difficult to filter on standard pressure or vacuum filters.

To all the pioneering work done by Oliver United engineers in connection with refinery filtration and clarification problems, can now be added pioneering work in the synthetic rubber field. A special Oliver Filter was designed for its operations and many of these filters are now in service.

Yes, Oliver United engineers are the ones who can bring you years of experience on filtration and clarification problems throughout industry generally and the petroleum industry in particular. Why not call on this experience?

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12-OUF-13

Crown Block for Portable Rigs

A NEW crown block incorporating important features in portable rig operations has recently been developed by Baash-Ross Tool Company, Los Angeles, California. The block is compact, and is so designed that simple over-and-over reaving of the drilling line is made possible. This feature eliminates cross-over of the lines and insures the traveling block rising and falling vertically without draft or "fleet angle," an important feature in the cramped quarters of portable masts.

A valuable construction feature of the new block is that all sheaves are mounted in line, so that all lines are parallel and in the same plane as they feed to and from the block. This not only prevents traveling block drift, but also eliminates pull-back from the center of the hole and reduces the risk of striking the inside bracing of the rig or the finger board. Pipe handling is made easier, as the derrickman does not have to contend with a twisting block when catching pipe, and the floormen do not have to work against the pipe swinging off center, the manufacturer states.

The new Baash-Ross crown block is made in two styles, type DCO and type DCS. Type DCS is designed for use where the fast line comes down the inside of the derrick, whereas type DCO is made for rigs where the fast line comes down to the drawworks on the outside of the rig. In this latter type, the fast line sheave is larger in diameter than the others, and is mounted eccentrically with respect to the bearing shaft of the other sheaves. This maintains the inline feature of all sheaves on the inside, but offsets the larger sheave on the back side sufficiently to carry the fast line outside the derrick without use of auxiliary sheaves or complicated reaving. The fast line operates on this larger sheave, thus reducing the rotational speed of the fast line sheaves instead of increasing it. Fig. 3 illustrates the type DCO block installed in the derrick. Note how the larger sheave is tangent to the others on the deadline side, yet is sufficiently offset to carry the fast line completely clear of the derrick and down to the drawworks.

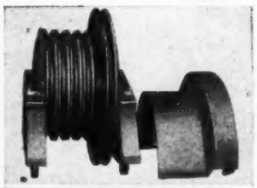

Figure 1. ABOVE BLOCK WITH COVER REMOVED SHOWING OFFSET ARRANGEMENT OF SHEAVE FOR OUTSIDE FAST LINE.

Figure 2. STRAIGHT-IN-LINE BLOCK FOR RIGS WITH FAST LINE INSIDE.

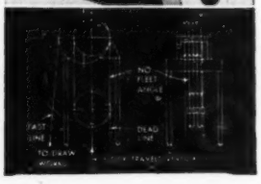

Figure 3. SHOWING ARRANGEMENT OF BAASH-ROSS TYPE DCO. CROWN BLOCK.

Another important feature of the Baash-Ross block is its unit-built design, which assures simplicity of installation and rigid sheave alignment at all times, according to the manufacturer.

More detailed information on this new Baash-Ross crown block can be obtained by writing direct to Baash-Ross Tool Company, 5512 Boyle Avenue, Los Angeles 11, California.

FOUR TESTED WAYS to make Brake Lining Last Longer

The suggestions given at the right are presented by Johns-Manville as proved methods of conserving drilling equipment, and of increasing the life and efficiency of brake linings.

1. **Check brake and clutch adjustment regularly** . . . to guard against unequal wear on friction materials.
2. **Don't box-in brakes and clutches** . . . Assure maximum heat dissipation by providing increased air flow.
3. **True up rims whenever scored or heat-checked,** to prevent unusually rapid wear of linings and facings.
4. **Don't try to control friction by using oil, clay or other such substances** on linings.

For further suggestions and for tips on how to secure longer life and higher efficiency from Packings, Insulations, Roofings and Refractory Cements, write for the new J-M Manual, "101 Suggested Good Operating Practices." Johns-Manville, 22 East 40th Street N.Y. 16, N. Y.

And for maximum efficiency, start rigs right* with

JM PRODUCTS

Johns-Manville 420 ROTARY LINING

*Write for Catalog FN-10A

THEY GAVE AMERICA A "FLYING START"

The following companies are operating or have under construction

59 HOUDRY AND T.C.C. UNITS

ASHLAND OIL & REFINING COMPANY
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THE PURE OIL COMPANY
RICHFIELD OIL CORP.
SINCLAIR REFINING COMPANY
SOCONY-VACUUM OIL COMPANY, INC.
SOUTHPORT PETROLEUM CO.
STANDARD OIL CO. OF CALIFORNIA
STANDARD OIL CO. (OHIO)
SUN OIL COMPANY
TIDE WATER ASSOCIATED OIL COMPANY
UNION OIL CO. OF CALIFORNIA

There has been no greater contribution to the war effort than catalytic cracking

As we near the second anniversary of America's declaration of war, we may well give due credit to the five leading oil companies which were first to adopt the Houdry Catalytic Cracking Process.

Whether by fate or foresight, they were ready. The day the dreadful news of Pearl Harbor broke upon an unsuspecting and unready America, these five companies—Socony-Vacuum, Sun, Magnolia, Tide Water Associated and Standard of California—had 14 Houdry catalytic cracking units in operation and two more nearing completion. Within a few months, most of these facilities had been converted to the manufacture of this war's most critical material, high octane aviation gas.

These pioneers of catalytic cracking soon were joined by other leading petroleum refiners. Sixteen companies are now operating or building Houdry and T. C. C. units. They include many of the industry's best known names and represent more than 50% of total U. S. refining capacity.

During two critical years of a war whose issues have been mainly decided in the air, Houdry licensees have carried almost the entire load of producing catalytically cracked aviation gas for the United Nations. Today, 23 out of the 27 catalytic cracking units in operation are Houdry-licensed units. Thirty-six more Houdry and T. C. C. units are being built.

Houdry Catalytic Processes and the Thermofor Catalytic Cracking Process are available to all American refiners, under license arrangements, subject to approval by the United States Government.

HOUDRY CATALYTIC PROCESSES
... FOR VICTORY IN WAR
... FOR PROGRESS IN PEACE

HOUDRY PROCESS CORPORATION, WILMINGTON, DELAWARE

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THE LUMMUS COMPANY
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Tough indeed! But war is also a proving-ground for men and machines. In such emergency, men learn the best way of doing things. Spang Cable Tools—plenty good now—will be better still after victory. Scarce now—they'll be plentiful when wartime obligations are fulfilled.

SPANG AND COMPANY
Butler Pennsylvania

SPANG
The Biggest Name in
CABLE TOOLS

Dozershovel

WITH a record of extensive service in the armed forces for whom it was designed and manufactured, a new two-in-one dirt moving unit—the Dozershovel for T9 and TD9 International TracTracTors—has been announced by Bucyrus-Erie Company.

Announcement of the Dozershovel comes as a result of production in excess of military demands, making limited numbers of this unit available for civilian use under government release.

The unusual design of the Dozershovel provides completely for full-fledged tractor shovel and bulldozer service, with simple interchangeability of bucket and blade permitting in-the-field changeovers in a few minutes. As a shovel, the unit's hydraulic control provides down pressure up to 4200 lb. for real digging "bites" and big pay loads in a short distance of travel. The same control on the bulldozer provides easy penetration in hard materials and ability to hold the cut. Strong side arms permit the shovel to lift big loads, the dozer to handle any dirt-dozing job. The unit's dumping trip mechanism gives the dozer ability to tip the blade forward to release the load on uphill dozing.

Other features include unobstructed visibility, low overhead clearance, oscillating tracks, and quick, high lift.

An additional feature is the standard hook on the upper edge of the shovel bucket or dozer blade, giving the unit a third application: lifting crane service. This is especially handy in loading or unloading the extra blade or bucket from the truck.

The changeover itself requires only simple operations: removing five pins holding the bucket, trip latch, and limit chains; setting dozer blades or shovel bucket in place; replacing pins.

Detailed information on the Dozershovel can be obtained from any International TracTracTor distributor or by writing Bucyrus-Erie Company, South Milwaukee, Wisconsin.

Joins Standard Steel

J. F. Bechtle has joined the Standard Steel Corporation, Los Angeles, California, as assistant general manager. He brings to this company wide experience

J. F. BECHTLE

gained through a 20-year association with the M. W. Kellogg Company in New York City. He was connected with the metallurgical and research department and was intimately associated with the development of welding and Pluramelt.

Knowles President Parkersburg Rig

At a meeting of the board of directors recently John M. Crawford resigned as

J. M. CRAWFORD

A. S. KNOWLES

president of The Parkersburg Rig and Reel Company, Parkersburg, West Virginia, and A. Sidney Knowles was elected as his successor.

Crawford, founder of the company in 1897, retires after 47 years' service. During this time, he was largely responsible for raising Parkersburg to the front rank of oil field equipment manufacturers.

Although relinquishing the presidency, Crawford is retaining his position as chairman of the board.

Knowles is already well known to a wide section of the oil industry and has been active in the operation of The Parkersburg Rig and Reel Company since becoming a member of the board of directors in 1936. He served in this capacity until October, 1942, when he was elected executive vice president.

WANTED

Engineer experienced in the rating and mechanical design of oil and gas separators for the petroleum industry.

Experienced heat exchanger rater and designer for oil refinery and chemical plant equipment for the petroleum industry.

Permanent positions with a well-established, growing firm located in the East Texas-North Louisiana area. Give complete information in first letter, including education, experience, age, draft status. If your qualifications fill the bill, conference will be arranged at our expense. Address: 301 City Bank Building, Shreveport 23, Louisiana.

☆

(Those now engaged in essential war work at their highest skill not solicited.)

In the Tight Spots—

"CLEVELANDS" Come Through!

"CLEVELANDS" built-in adaptability to meet the many varied field conditions enable them to handle the toughest ditching jobs on the roughest going and in the tightest spots.

Some of the reasons why "Clevelands" come through under the most adverse conditions are:—

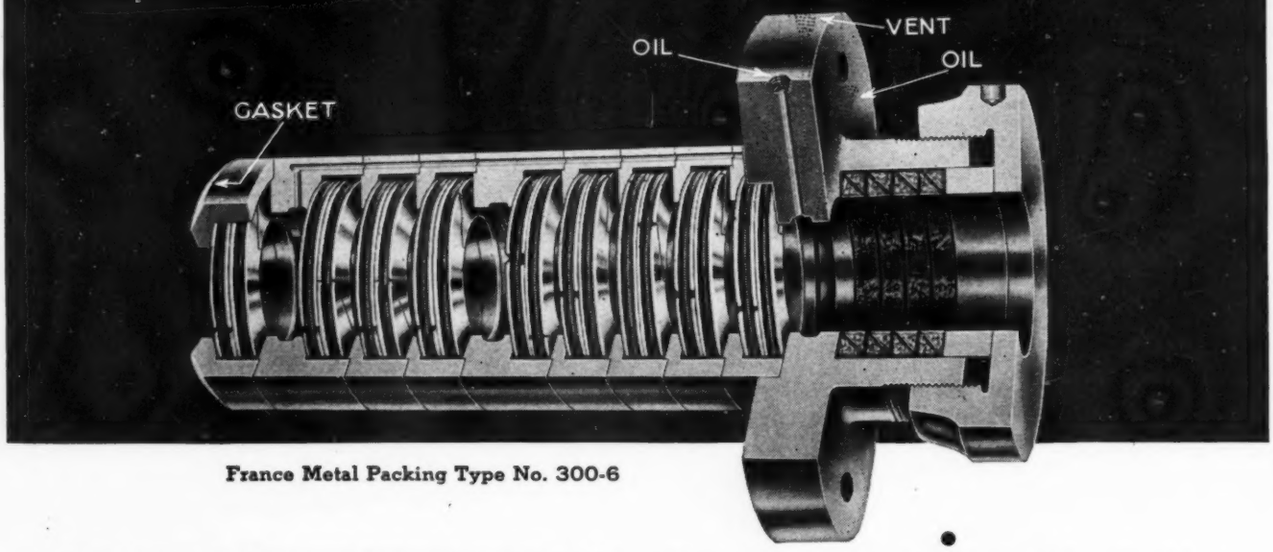
1. Their correct, compact, time-tested, clean cut, wheel-type design.
2. Superior construction, modern engineering and mechanical excellence assures strength and ruggedness with the elimination of excess weight and bulk.
3. Extreme ease of operation and maneuverability because of broad full crawler mounting.
4. The quickly reversible Arc Conveyor permitting the throwing of dirt on either side of the ditch at desired distance.
5. A multiplicity of digging and traction speeds always available to operator, enabling him to cut at maximum speeds for the work at hand.
6. Ample power to carry through in any soil and over the toughest terrain.

These are some of the reasons why CLEVELANDS have been preferred equipment for the digging of hundreds of miles of pipe line ditch and why they are in use today on many varied government war projects.

THE CLEVELAND TRENCHER COMPANY
20100 ST. CLAIR AVE. "Pioneer of the Small Trencher" CLEVELAND 17, OHIO
"CLEVELANDS" Save More... Because they Do More

INSTALL FRANCE METAL PACKING

For Uninterrupted Gas Compressor and Gas Engine Service



France Metal Packing Type No. 300-6

This type of packing was designed especially for gas compressors in order to handle the many and varied gases as well as the higher pressures and temperatures now encountered.

One of its outstanding advantages is the fact that it is provided with lubrication where most essential, that is, beyond the first pair of rings. Additional lubrication is provided between the packing in the main stuffing box and that in the auxiliary stuffing box. A provision for venting is also contained in the assembly.

Furnished either with or without the auxiliary stuffing box arrangement, depending on the type of gas and the operating conditions. The number of pairs of rings in the main stuffing box is governed by the pressure and operating conditions. The main stuffing box rings are made from the material which we have found from experience to be best suited for the type of gas encountered—cast iron, bronze, micarta or carbon.

France Type No. 285 Gas Engine Packing

Designed with special consideration for the extremely high temperature conditions under which it operates. France Engineers are well experienced in furnishing packing for this service.

Like the many other types of packing we design, these types are manufactured with the utmost care by mechanics with years of experience and carry our usual guarantee of satisfaction.

If you are interested in packing that l-a-s-t-s, packing that remains t-i-g-h-t and requires minimum attention, then write for detailed information that will apply to your particular requirements.

Ask for illustrated Catalog No. M-3

The France Packing Company
Tacony, Philadelphia 35, Penna.

ORIGINAL FRANCE METAL PACKING

Specialists in the design and manufacture of

The Original France Metal Packing for all conditions of service

Mills Hammett Passes Away

David Mills Hammett, vice president of Axelson Manufacturing Company, died the evening of November 30 at his home in Whittier, California. Death came as a result of complications from pneumonia, followed by a heart attack. Services were held December 3 at Forest Lawn Memorial Park, Glendale, California. Hammett was born at Pine Bluff, Arkansas, June 13, 1884.

D. M. HAMMETT

Surviving are his widow, Mrs. Edna Hammett of Los Angeles, California; a son, Mills, Jr., of Glendale, California, and a daughter, Mrs. John Furneaux, and granddaughter, Eunice May Furneaux both of Bakersfield California.

Gold Star to Wm. Powell Company

James Coombe, president of The Wm. Powell Company, Cincinnati, Ohio, announces he has been notified by Admiral Vickery, chairman of the United States Maritime Commission, that the Powell company has been awarded a gold star to be added to the Maritime "M" Pennant presented last May. This is in accordance with the commission's practice of granting an additional gold star every six months to companies whose production performance merits the award. In addition to its gold-starred Maritime "M" Pennant the Powell company has also won the Victory Fleet Flag and the Army-Navy "E".

Manager of Sales

Stuart E. Yeaton native of Seattle, Washington, and graduate of the University of Washington, has been made manager of sales of the electrical wire and cable division of the John A. Roebling's Son's Company, Trenton, New Jersey. Subsequent to his graduation from the university he was employed as a salesman in the Seattle branch from 1934 to 1941, at which time he was made assistant to W. G. Marks, president of the California Corporation of the Roebling company at San Francisco. In May, 1943, he was transferred to the main office at Trenton as manager of sales of round, flat wire and specialties.

S. E. YEATON

Receives Award

Chiksan Tool Company, Brea, California, was awarded the Army-Navy "E" Pennant for excellence in war production at formal ceremonies at the Chiksan plant recently. Presentation of the pennant was made by Rear Admiral J. R. Defrees, U.S.N. (Ret.). W. Edgar Spear, president of Chiksan, accepted the award in behalf of all Chiksan employees. "E" pins were presented by Lieut. Col. Henry E. Beal, U.S.A., and accepted by Van J. Kubin, oldest Chiksan employee. Chiksan manufactures swing joints and oil tools.

Change Firm Name

Staynew Filter Corporation, Rochester, New York, will henceforth be known as Dollinger Corporation, taking this name from Lewis L. Dollinger, president and founder of the company.

Recently expanded manufacturing facilities have made possible the development of new products that are soon to be announced. As certain of these are products other than filters, the company name is changed to one of a more general character.

Staynew and Protectomotor trade marks will be used for filter products. There is no change in the management.

The preposterous elaboration in the Tower of Babel led only to confusion. We must all avoid visionary projects.

The HILL-HUBBELL post-war program is sanely conceived, and will be carried out *practically*.

Your Steel Pipe Protection needs will be met by improved methods, streamlined to handle all reasonable demands.

HILL-HUBBELL Steel Pipe Protection is applied at these leading mills.

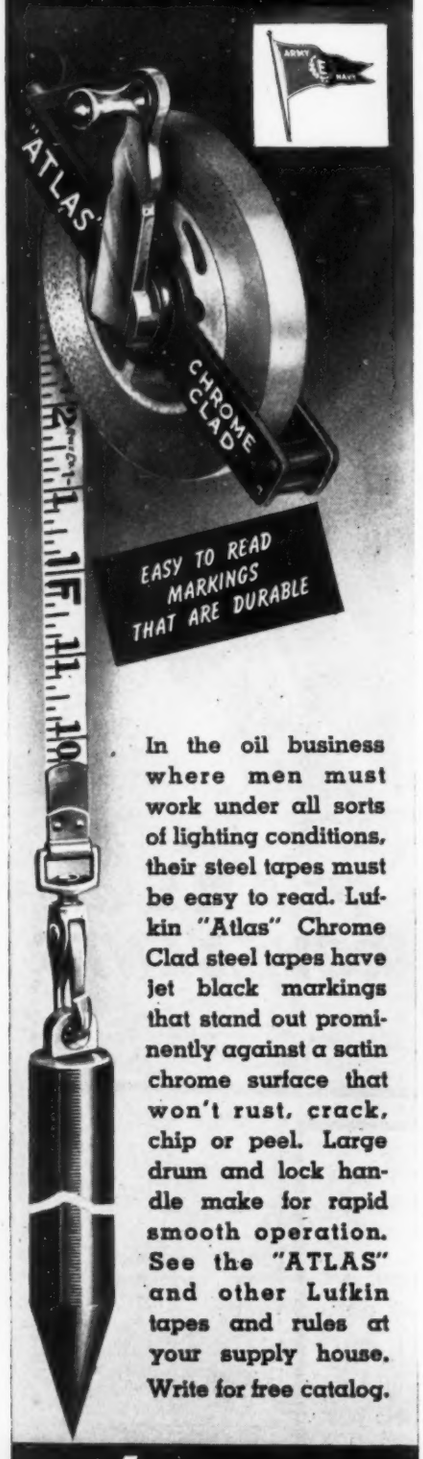
Jones and Laughlin Steel Corporation

National Tube Company

Spang - Chalfant

GENERAL PAINT CORPORATION
HILL, HUBBELL & CO. • Division • Cleveland, Ohio
• EXPORT OFFICE: SAN FRANCISCO, CALIFORNIA, U. S. A. •

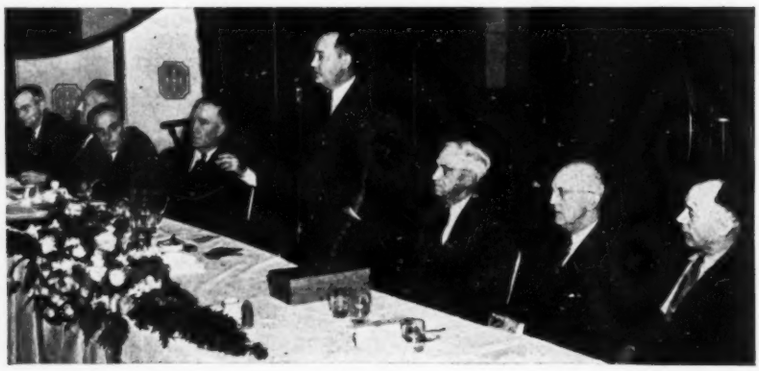
"ATLAS"
CHROME CLAD
STEEL TAPES



In the oil business where men must work under all sorts of lighting conditions, their steel tapes must be easy to read. Lufkin "Atlas" Chrome Clad steel tapes have jet black markings that stand out prominently against a satin chrome surface that won't rust, crack, chip or peel. Large drum and lock handle make for rapid smooth operation. See the "ATLAS" and other Lufkin tapes and rules at your supply house. Write for free catalog.

LUFKIN
SAGINAW, MICHIGAN • New York City
TAPES · RULES · PRECISION TOOLS

Service Pins Presented to Baker Employees



Recently Baker Oil Tools, Inc., held the second annual service pin banquet for its California division. Left to right are: R. C. Baker, Jr., S. J. Ralston, G. M. Anderson, E. E. Pyles, guest speaker, T. Sutter, R. C. Baker, C. A. McDonald, A. C. Pazdernik. All Baker employees pictured are 20-year service men, as are also T. H. Arney, A. A. Baker, and A. H. Lake, who were unable to be present. A total of 31 employees were honored with pins representing five years, or more of loyal service.

Eight employees of the central division of Baker Tools, Inc., received service pins at a similar banquet held at Houston, Texas, on November 19, 1943.

New Superior Engine Lab

To speed the development of better diesel engines—not only for present war use, but, particularly, for peacetime industrial and marine applications—the Superior Engine Division of The National Supply Company recently placed in operation at its Springfield, Ohio, plant one of most complete engine research laboratories in the country.

Researchers at this giant new laboratory are currently engaged in testing Superior diesel engines now in production and in developing and testing new types in the experimental stage.

Exterior view of research laboratory at Springfield, Ohio.

The new laboratory is completely equipped, having a vast collection of modern research apparatus and the finest-testing machines and instruments available. Much of this equipment was especially designed for the study, analysis, and testing of diesel engine performance.

In addition, the laboratory is equipped to make engine fuel and lube oil consumption tests; engine heat balance tests; engine noise level tests; intake, exhaust, and cylinder pressure studies using Maihak, Cox or R.C.A. pressure recording equipment; water and lube oil pump calibrations and tests; Bosch fuel pump and nozzle tests, calibration, and adjustment; tests of governors and general engine accessories; studies of engine vibration characteristics covering torsional, lateral, and wheel shimmy characteristics; dynamic strain measurements; visual study of vibration of engine parts and studies of generator voltage wave form.

The chemical and metallurgical laboratory has, among other equipment, apparatus for microscopic examination of metals; chemical analysis, gravimetric and volumetric; spectrophotometric analysis; physical testing, including 120,000 lb. universal testing machine with stress strain recorder; fatigue testing and impact testing; heat treating; profilometer; hardness testing and magnaflux testing.

The new laboratory, which, with equipment, cost approximately $500,000, is of brick, stone, and glass block construction, 231 ft. long by 100 ft. wide. There are no windows—lighting is by an improved fluorescent system.

HIGHER CUTTING EFFICIENCY from SEISMOGRAPH BITS

Hard-Facing Recommendations For Obtaining More Footage—Faster Cutting—Less Down-Time For Bit Resharpening

1. Always include at least one Borium insert at the lower, outside corner of each cutting wing to prevent "diamond pointing." (Sketch)

2. On bits larger than 6 inches O.D a second Borium insert on the lower cutting edge improves drilling efficiency. (Sketch)

3. Cover leading faces of all bit wings with Tube Borium, using screen size of at least 10-20 mesh rather than finer meshes such as 30-40. Tests conclusively prove the larger Borium particles greatly increase drilling speeds.

4. Don't skimp on quantity. Tests show that bit life and efficiency is in direct proportion to the amount of Tube Borium applied (up to ⅛" in thickness).

More Seismograph Bits Are Hard-Faced With Tube Borium Than Any Other Alloy

STOODY COMPANY

1142 West Slauson Ave., Whittier, Calif.

STOODY HARD-FACING ALLOYS
Stop wear... Eliminate Repair

Corrosion Engineers Form New Association

The National Association of Corrosion Engineers is the name of a new organization now being formed. This body is the outgrowth of the Cathodic Section of the Petroleum Industry Electrical Association, and prior to that the Mid-Continent Cathodic Protection Association.

Since 1940 the members of the association have been meeting and carrying on their activities as the Cathodic Section of P.I.E.A. This group has enjoyed a steady growth and has attracted the attention and interest of an increasing number of persons engaged in the work of corrosion prevention. It is now felt that the body is sufficiently large to justify a separate association.

All persons engaged in the work of corrosion control or mitigation on underground metallic structures are invited to apply for membership. Inquiries should be directed to O. C. Mudd, acting secretary-treasurer, Shell Pipe Line Corporation, Box 2648, Houston 1, Texas, or to R. A. Brannon, acting president, Humble Pipe Line Company, Drawer 2220, Houston 1, Texas.

Assistant to President

E. P. Holder, president of Wickwire Spencer Steel Company, has announced the appointment of Robert T. Dunlap as assistant to the president.

Prior to joining Wickwire Spencer Dunlap was general works manager of the Vulcan Iron Works at Wilkes-Barre, Pennsylvania. He has also been associated with the Elliott Company, Jones and Laughlin Steel Corporation, and the Pittsburgh Bridge and Iron Works.

He will make his headquarters at the company's home office at 500 Fifth Avenue, New York 18, New York.

If You Are a

MECHANICAL ENGINEER

with experience in oil field equipment design, capable of assuming the responsibility of developing new and improved oil tools, and desire permanent employment with an organization that has a proven reputation and a bright future, write to:

Chief Engineer

Cameron Iron Works, Inc.

711 Milby Street, Houston 3, Texas

State fully your experience, education, previous and present employment, etc. If now engaged in essential war work at your highest skill, do not apply. Your letter will be treated with strict confidence.

VICTORY . . . AND LIBERTY

It's Time to Make Postwar Plans

Victory by our Armies means new liberty for Postwar activity. Manufacturers and municipalities then can, and will be expected to go ahead with plans of progress.

Those new plans will unquestionably include Wells and Pumps to supply an adequate amount of water—water that can be produced at exceptionally low cost. The Layne Organization has foreseen and made many plans for the days of Postwar. Highly improved designs—some of which were evolved to solve critical war needs, will be instantly available for factories and cities throughout the Nation.

Layne Well Water Systems have long enjoyed absolute superiority in highest efficiency. They have established and maintained thorough dependability. Their quality has been proven by nearly three quarters of a century of service. They are better built today than even before.

For Postwar Water System planning, write for illustrated literature on Layne Pumps and Layne Well Water Systems. Address, Layne & Bowler, Inc. General Offices, Memphis 8, Tennessee.

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. * Layne-Atlantic Co., Norfolk, Va. * Layne-Central Co., Memphis, Tenn. * Layne-Northern Co., Mishawaka, Ind. * Layne-Louisiana Co., Lake Charles, La. * Louisiana Well Co., Monroe, La. * Layne-New York Co., New York City * Layne-Northwest Co., Milwaukee, Wis. * Layne-Ohio Co., Columbus, Ohio * Layne-Texas Co., Houston, Texas * Layne-Western Co., Kansas City, Mo. * Layne-Western Co. of Minnesota, Minneapolis, Minn. * International Water Supply Ltd., London, Ontario, Canada.

LAYNE
WELL WATER SYSTEMS
DEEP WELL PUMPS

Builders of Well Water Systems for every Municipal and Industrial Need

TWO YEARS OF CALLING ATTENTION TO SAVING CHROMIUM
This advertisement ran in 1941.

SAVE CHROMIUM
HELP NATIONAL DEFENSE

You can save chromium for defense and save money in your own plant by using our Chrom Glucosate. You are wasting chromium, badly needed in our National Defense program, when you use it for corrosion control instead of chrom glucosate.
Look at this table of comparison. It tells a commanding story.

COMPARATIVE CHROMIUM CONSUMPTION USING GLUCOSATES AS COMPARED TO CHROMATES

Amt. in form of Glucosate	Amt. as dichromate	Application	Saving
SODIUM BICHROMATE			
17 pounds	100 pounds	Calcium Brine	83 lbs.
17 pounds	200 pounds	Salt Brine	183 lbs.
34 pounds	500 pounds	Cooling Water	466 lbs.
CHROMIC ACID			
3 pounds	66 pounds	Calcium Brine	63 lbs.
3 pounds	132 pounds	Salt Brine	129 lbs.
10 pounds	330 pounds	Cooling Water	320 lbs.

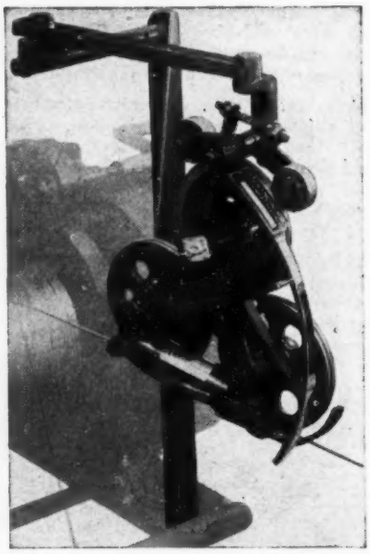
Help us to stop the waste of chromium ore. Switch to Chrom Glucosate at once and tell your business acquaintances the story of Chrom Glucosate too.

Furthermore, there are other glucosates that eliminate the need of chromium. Let us send you the whole story.

WATER CONSULTANTS

D. W. HAERING & CO., INC.
GENERAL OFFICES: 205 West Wacker Drive
CHICAGO, ILLINOIS

ACCURATE Depth Measurement



with a MATHEY
MEASURE METER and WEIGHT INDICATOR

Type B Measure Meter and Weight Indicator, pictured here, gives accurate measurements and eliminates the factor of human error, by indicating on easily read dials, the weight and length of line in the hole.

It is adaptable to all units using measure meters, and is built for any size measuring or torpedo line.

PORTABLE MEASURING UNITS

For depth work, with reel capacities from 5,000 feet to 15,000 feet of .072 line. Seven models available for mounting in trailers, cars, pulling-units and core drills. Self-powered by gasoline engine or power take-off models.

Write for Descriptive Literature

Gas Testing Equipment—Measuring Meters
Reeling Equipment for Well Shooting
Oxy-Acet Pipe Beveling Machines
Designers, Manufacturers of Special Machinery

WRITE FOR DETAILS

C. A. MATHEY MACHINE WORKS
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Twenty-fifth Anniversary

A nebulous idea, conceived and nurtured to a feeble start 25 years ago in the seemingly unrelated atmosphere of a bicycle shop, provided the foundation

FRED E. COOPER

for one of the modern oil industry's outstanding lines of mobile well servicing units.

Small wonder then, that Fred E. Cooper, Tulsa, Oklahoma, world wide manufacturer and distributor of Allis-Chalmers oil field well servicing equipment, takes pride in the twenty-fifth anniversary in the business he founded and developed.

The motives and incentives that inspired Cooper to develop winch equipment for a conventional tractor 25 years ago—the objective of saving time, steel, and manpower—are applicable with redoubled emphasis under existing war conditions. Development of full integrated and portable well servicing and drilling equipment on the whole has been a gradual refinement of the original machines. Still, the modern units, with their highly selective ranges of power, speed, weight, and auxiliary equipment are a far cry from the first Rumley tractor with winch attached, which Fred E. Cooper demonstrated to skeptical production men in the Ponca City area a quarter of a century ago.

The outstanding feature of all portable well servicing equipment and oil field power units is the speed and simplicity of operation and the drastic economy in steel. A single tractor type servicing unit, experience from various parts of this country and foreign fields confirms, are capable of maintaining 20 to 100 wells, depending on the variable factors of spacing, terrain, well depths, and required frequency of attention.

The Fred E. Cooper arrangement with Allis-Chalmers is unique in the petroleum equipment industry. Tractors are built to Cooper specifications, including special transmissions and wheel brakes. The manufacturing oper-

For Fred E. Cooper

ation performed by Cooper in production of well servicing equipment and oil field power units includes a wide range of modifications and installation of special equipment. In some combinations little remains of the original tractor delivered to Cooper's plant except the engine. Rubber-tired wheels are used. The narrow, conventional tractor front axle is replaced with one that separates front wheels to the standard highway gauge. Single or dual winches for pulling and running rods, tubing, drill pipe, bailer, fishing tools, and drilling bits are installed at the option of the purchaser. Either telescoping single or double-pole masts are finished, equipped, and installed on the service units at the Cooper plant.

Circulating air cooled brakes on the winches are a special patented feature of all units. The brakes were developed by Fred E. Cooper during his early experimental work in perfecting the adaptation of tractors to well servicing equipment. In all cases, irrespective of the braking surface, lining is installed and supplied in 8 in. widths, or less. Lining of greater width, Cooper's engineers assert, is more likely to burn, gall, and fray, leading to troublesome delays in operations and to reduced overall efficiency of the units. The patented fins are so arranged and constructed as to force air into the zone of contact between the drum and brake band, resulting in one of the most satisfactory cooling systems available on portable hoisting equipment.

Scope of the oil field work that the tractor and skid-mounted units are qualified to perform in field operations are infinite. Units are designed for specific ranges of service but the margin of flexibility in all models embraces functions of drilling, servicing, reconditioning, deepening, and completing wells.

Tractor type well servicing units are available in four general models but optional equipment of dual drums increases the selectivity. Furthermore, the wheel assembly is available in numerous combinations. For service in areas where seasonal mud hampers transportation of heavy equipment, the tractor-type units are available with dual balloon tires on each rear wheel and balloon tires on front, imparting a "floating" buoyancy on the equipment that permits portability in all weather short of floods.

Maximum line pull by tractor type servicing units is 66,730 lb. for the Model L, which is equipped with a 6-cylinder, valve-in-head motor with 5¼ in. bore and 6½ in. stroke. Displacement of the engine is 844 cu. in. Rotary drive and spudding equipment is avail-

(Continued on Page 172)

Here's how to make your present Valves LAST LONGER..SERVE BETTER

● Experience shows that even the best valves last longer and serve better if given periodic inspection . . . and repairs when necessary.

Today when new valves and even repair parts are scarce and require high priorities, it is more essential than ever to take good care of your present valves.

The Lunkenheimer "N-M-D" Valve illustrated is typical of the simple, rugged, easy-to-maintain construction that distinguishes Lunkenheimer design practice.

Thus maintenance men working with these valves find them easier to keep fit and on the job. . find that Lunkenheimer valves will last longer and serve better with less attention and time out for repairs.

Use the complete facilities of Lunkenheimer distributors.

Simplicity of Design Means Easier Maintenance

Disc can be renewed in a jiffy. Simply unscrew locknut from disc holder, remove old disc and insert new one—reassemble and the valve is ready for use. Or better still, keep on hand some spare disc holders complete with discs — slip a disc holder and a new disc on the stem and remove the old disc from the holder later.

LUNKENHEIMER VALVES

(Continued from Page 171)

able for all winch units. Telescoping masts are available. The Model L has 8 line speeds on the drum, ranging up to 1059 ft. per minute at 1200 r.p.m. on the engine. The most recent designed spudder attachment is of the variable stroke, crank type. The crank is equipped with four pin holes, giving tool strokes of 27, 35, 43, and 55 in. The masts for all Cooper units are built with deep groove sheaves made of manganese alloy steel, 23 in. in diameter. Sheaves are ball bearing mounted on a 2¾ in. alloy-steel shaft. The engine has a continuous operating range of 600 to 1200 r.p.m. Torque is 50 ft.-lb. at 650 r.p.m. Engines operate either on gasoline, butane, natural gas, or distillate.

The smallest unit of the Allis-Chalmers and Cooper line of tractor-type servicing units is the Model W, which resembles its larger companion assemblies except that the engine, winch, weight, and other characteristics are scaled down in order to provide a compact streamlined unit built to handle up to 3500 ft. of 2 in. tubing, or other well servicing assignments involving weight within the maximum line pull of 20,666 lb.

The Model L drilling unit is the heaviest machine in the Allis-Chalmers and Cooper line. It is available as a winch tractor or as a skid winch unit for servicing the deepest wells. The transmission in this unit is built especially to withstand the heavy shocks in the deeper services to which it is customarily assigned, and for the more severe conditions encountered both in rotary and cable-tool drilling. The transmission is not the conventional automotive type. On the contrary, the heavy duty gears are manufactured in the Cooper plant from alloy-steel and are subjected to run-in tests that assure as far as possible trouble free operation in the field. The unit is powered with a slow speed 6-cylinder power unit that has a bore of 5¼ in., a stroke of 6½ in., and a piston displacement of 844 cu. in.

When designed specifically for rotary or cable-tool drilling the Model L unit is equipped with two drums, cathead, rotary drive, and spudding equipment.

Tractor-type equipment customarily is supplied with supports for cradling the mast across the longitudinal axis of the unit. Clamps hold the mast, whether it be the telescoping single or double pole type, to the supporting members, which extend above the maximum height of the winch drum and other mechanism. The forward support of the mast cradle serves as a fulcrum over which the mast is hoisted into an upright position. Hoisting lines are attached to the base of the mast and are taken up by the regular winch, which is an integral part of the machine. The masts are available in

A Good Insurance Policy

to promote boiler life and efficiency is the Consistent Use of

SAND-BANUM

Automatically

removes and prevents scale and corrosion in absolute safety to equipment and personnel while your equipment operates.

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"The Entirely Different Boiler and Engine Treatment"

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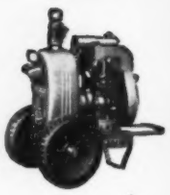
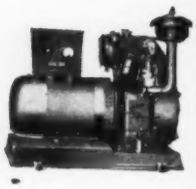
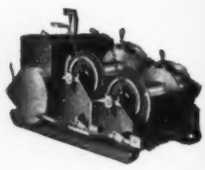
LEADING CONTRACTORS PREFER Sterling
PUMPS • HOISTS • LIGHT PLANTS







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Use CURTIN CENTRIFUGES

No. 3420 15 c.c. machine . . . . Cranks and heads interchangeable with 100 c.c. machines.

Simple in design . . . Ruggedly built . . . Require no special care . . . Great Ratio and throw of crank produce required speed with no strain. Curtin Centrifuges meet all A.S.T.M. Standard Method D-96-40 and A.P.I. Code No. 25 requirements. Fully descriptive literature upon request.

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HOUSTON U.S.A. TEXAS

Look for the Arm-and-Hammer
ARMSTRONG BROS.
CHAIN TONGS

ARMSTRONG CHAIN TONGS have been engineered to overcome the weaknesses discovered in ordinary tongs. They are stronger, last longer and are more convenient.

Jaws are drop forged, with milled teeth, are heat-treated and extremely tough. They have inner lugs which increase the bearing on the bar and also prevent chains from jamming. Other strength features include forged handles, large hardened steel bolts, alloy steel shackles and proof-tested chains.

ARMSTRONG BROS. Tongs come in *all* standard types, each in *all* sizes.

Write for Catalog.

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
331 N. FRANCISCO AVE. CHICAGO, U.S.A.
Eastern Warehouse & Sales: 199 Lafayette St., New York

extended heights of 40 to 60 ft., depending on the size of the unit and the work is expected to perform. Height of the mast is largely optional with the operating company.

Manufacture and distribution of well servicing and oil field power units are only two of the three functions performed for the petroleum industry by the Fred E. Cooper organization. The third function, and one that testimonials indicate is most valuable in field operations, is the servicing of units. All engine and equipment parts are standardized to a degree uncommon in the petroleum or any other industry. Many parts for the various sized units are interchangeable, giving operators in the field maximum protection against enforced idleness of equipment regardless of the degree of essentiality of work in which the units may be engaged.

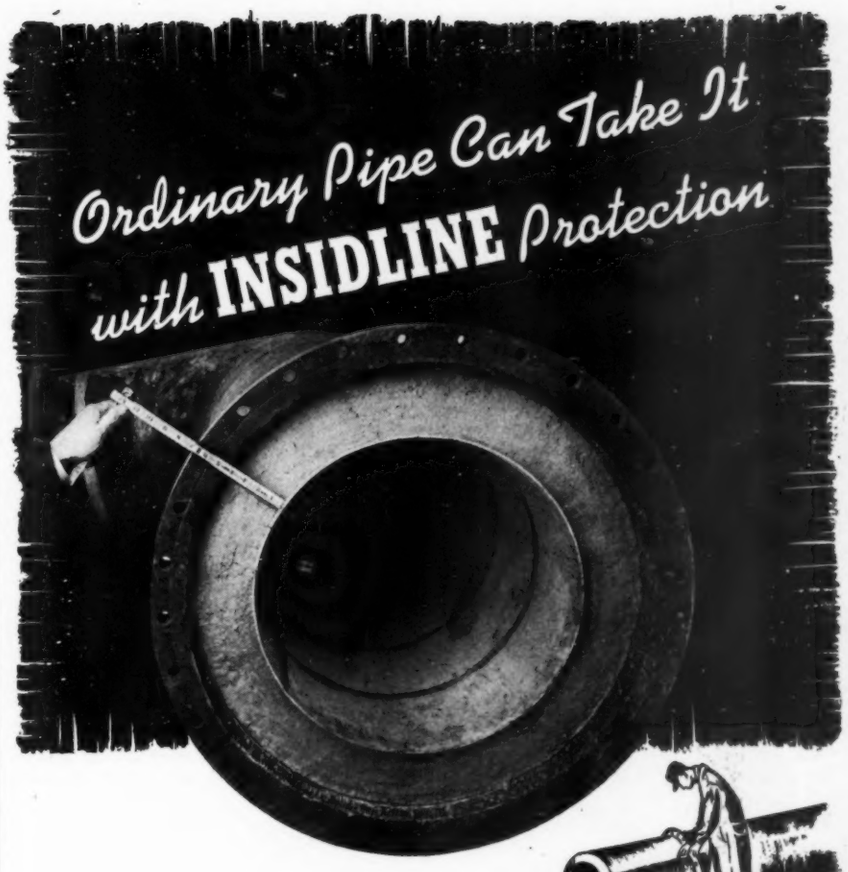
A complete stock of repair parts and service are maintained at the Cooper plant and distribution centers. Overnight service on repair parts is one of the features on which the organization has been built.

The Tulsa plant is organized on an assembly line basis. A new order for a specific model of well servicing or power unit goes to the stockroom where every part required for the manufacturing operation, down to the smallest key, is collected by the storekeeper and transferred as a unit to the shop. Special equipment to meet the specifications of the particular user of the unit to be built is made in the shop. Brakes are turned out on precision lathes and ground to a mirror polish. The brake drums are weighed on a wheel-spinning machine and counterbalanced to avoid vibration and uneven wear on the brake lining and band. Sprockets and special gears are machined in the Cooper shop. Power shafts are installed, control levers mounted and connected, road gears adjusted, and other steps taken in the manufacturing operation.

First tractors of the Advance-Rumely Company, to which a Cooper winch was attached, has a road speed of 4 m.p.h. but even in the early days of portable well servicing equipment this comparatively slow transfer from one location to another was much faster than the previous time required by the single cylinder gas engines employed for clean out and other operations.

Star Added

A star has been added to the Army-Navy "E" Flag of Ladish Drop Forge Company, Cudahy, Wisconsin. This government award is in recognition of continued effort and excellence in the production of drop forgings and fittings for military use. The flag was presented on April 14, 1943, and the star awarded six months later.



Insidline installations in pipe from 2" I. D. to 36" I. D. are made with a cartridge type of insulation that is built up first and then drawn into the pipe.

Insidline is a carefully built-up insulation for the inside of pipe. It eliminates the necessity of expensive, hard to get, high-alloy, steel piping for new industrial processes requiring high-temperature gases and vapors under pressure. With this inside insulation, ordinary carbon steel pipe can be made to handle gases up to 1800°F., at high pressures and velocities.

By keeping the pipe temperature at 750°F., or below, "creep" is prevented and the usual stress allowances permit indefinite operation. The number of expansion joints, bends, and other provisions for pipe expansion are greatly reduced, with resultant simplification of design and construction economies. Our engineering staff will gladly consult with you on the application of Insidline to your particular piping problem.

In larger diameters from 36" up to over 100" a panel type of Insidline is built up on the inside of the pipe.

Send for descriptive booklet.

BH

BALDWIN-HILL CO.

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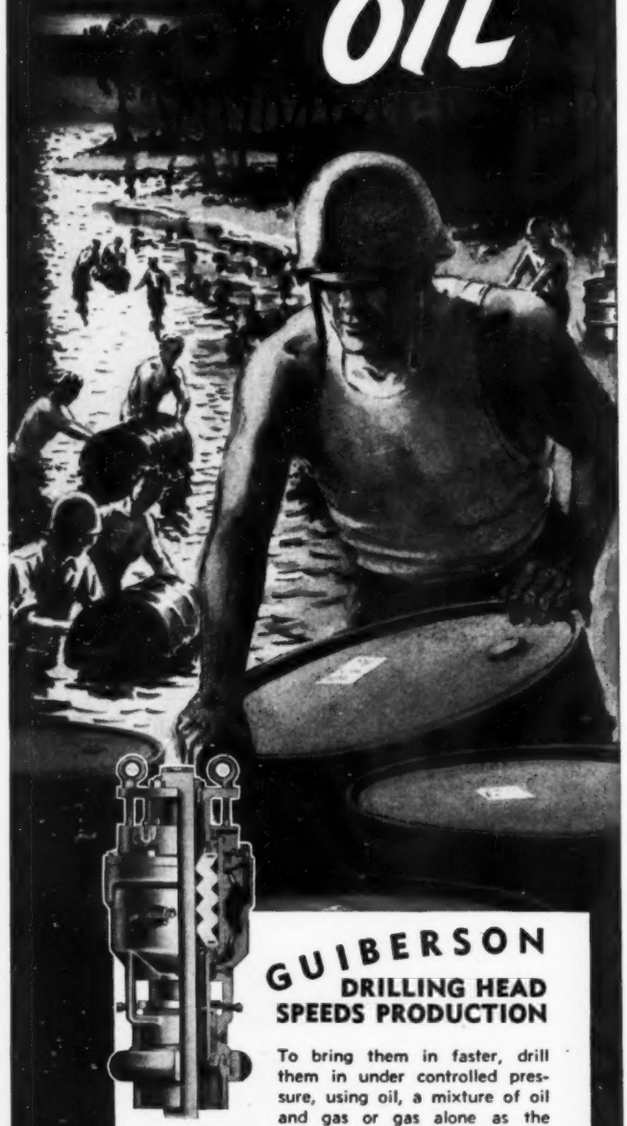
ALL OVER THE WORLD THE CALL IS FOR OIL



GUIBERSON DRILLING HEAD SPEEDS PRODUCTION

To bring them in faster, drill them in under controlled pressure, using oil, a mixture of oil and gas or gas alone as the circulating column. And for top effectiveness, standardize on the GUIBERSON DRILLING HEAD—the time-tested rotating pack-off that offers safety for the men and positive protection against blow-outs . . . Used for cleaning out in the usual manner, or by reverse circulation after shooting, the GUIBERSON DRILLING HEAD makes a better well in **one-tenth** the time . . Write for details or see your Composite Catalog.

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Now supplying critical materials to the Army, Navy, Marines and Army Air Forces

GUIBERSON
LIFE EXTENSION SERVICE FOR OIL WELLS

Book Reviews

Review of Petroleum Geology in 1942, by F. M. van Tuyl. Published as the July Quarterly of the Colorado School of Mines, Golden, Colorado. Pages, 75. Price, $1.

This work, sponsored by the Research Committee of the American Association of Petroleum Geologists, is a compilation of progress in this field, the trends developed and the events that marked the year which it covers. Included are a list of 209 references to publications of 1942 and, a catalog of events, news items, conferences and investigations in the fields of geology, geophysics, geochemistry, geobiology, petroleum engineering, and aerial photography.

The editor of the Quarterly has announced that each April number of the publication from now on will be composed of a review of the preceding year.

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Some Tools and Methods Used in Cleaning Oil Wells in California, a report of investigations by G. B. Shea. Published by Bureau of Mines, United States Department of Interior, Washington, D. C. Pages, 39.

One way of increasing the efficiency of oil-well operation has been due to advancements in the art of cleaning wells, Shea points out in his introduction to this detailed report on well cleaning in California. Reading of the assembled material should stimulate interest in the innovations and new methods and tools being used in this important operation and perhaps create additional improvements in practice. Popular tools are shown in photographs and diagrams.

Larry Succop Killed in Action

Word has just been received by Clarence F. Succop, president of American Roller Bearing Company, of the death of his son, Lt. Larry N. Succop, who was killed October 17 in the New Guinea area while flying a fighter plane with the Fifth Air Force.

LT. LARRY N. SUCCOP

Lt. Succop had enlisted in March, 1941, before Pearl Harbor, and been on active combat duty for 13 months in the Pacific campaign. He was decorated five times, having received the air medal and one oak leaf cluster, the distinguished flying cross and two oak leaf clusters.

He will be mourned by his many friends made throughout the Southwest, where he traveled during 1940-41 as sales representative of American Roller Bearing Company.

Lt. Succop was a graduate of Shadyside Academy, Yale University, and Carnegie Tech. He is survived by his widow, Ann Archer Succop of Phoenix, Arizona; by his parents, Mr. and Mrs. Clarence F. Succop of Oakmont, Pennsylvania; and by his brother, William G. Succop, formerly of Houston, Texas, and now living in Pittsburgh, Pennsylvania.

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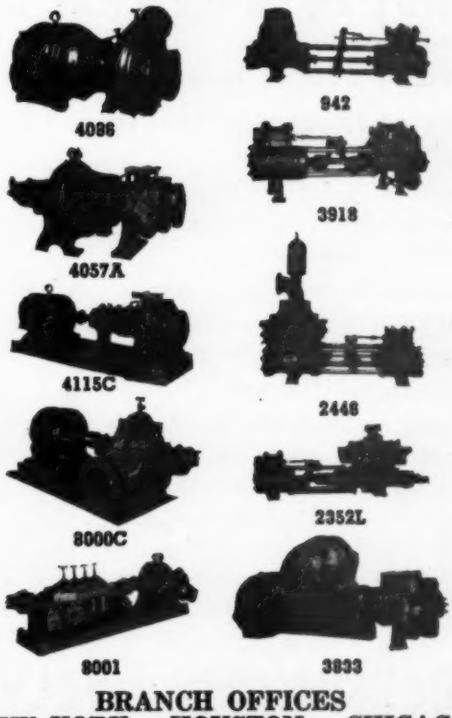

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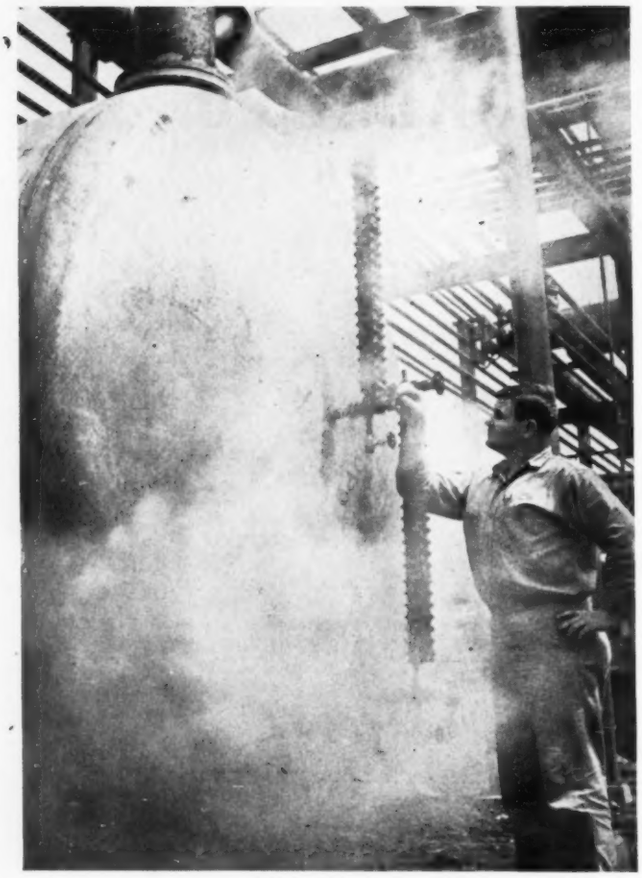

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TRADE LITERATURE

What to Write For

MAXIM WASTE HEAT BULLETINS, WH 100, 102, and 103, are available upon request to The Maxim Silencer Company, 90 Homestead Avenue, Hartford, Connecticut. These describe in detail the construction of Maxim heat recovery silencers and how they save fuel.

EXTRAORDINARY TESTS can be given Rolagrip pipe couplings for plain end pipe, according to literature giving information on the subject which will be sent upon request to Gustin-Bacon Manufacturing Company, Kansas City 7, Missouri. Endurance of the couplings is explained and verified.

TIME AND MONEY saving possibilities of the reducing elbow in welded piping systems are the subject of Bulletin WF-41, published by Midwest Piping and Supply Company, 1450 South Second Street, St. Louis, Missouri. The reducing elbow takes the place of a standard elbow and a reducer.

"THE PROFITABLE OPERATION of an Oil Field Electric Plant," a 12-page booklet, tells the story of how an oil company bought its own plant in five years. Copies will be sent upon request to The Cooper-Bessemer Corporation, Mount Vernon, Ohio.

STANDARD AND SPECIAL TYPES of Vogt heat exchangers are described in a new bulletin HE-5, which carries many illustrations. Henry Vogt Machine Company, Inc., Louisville 10, Kentucky, has copies for distribution.

G-R BENTUBE SECTIONS, their uses and their popularity, are described and pictured in a bulletin published by the manufacturers, the Griscom-Russell Company, 285 Madison Aveneu, New York 17, New York.

A GUIDE for the selection of packing is contained in a bulletin published by Greene, Tweed and Company, Bronx Boulevard at 238th Street, New York 66, New York, who will send a copy upon request. The bulletin tabulates more than 36 different fluids handled in process work and general plant services and lists the correct packing for each liquid, gas, and vapor.

THE BROWN FINTUBE COMPANY, Elyria, Ohio, has released Bulletin 432 describing its newly improved BFT-1 sectional hairpin heat exchangers. Descriptions and performance data, design and structural features are included in the folder.

AN 18-PAGE CATALOG produced by Chain Belt Company, Milwaukee, Wisconsin, gives complete information about Rex speed prime pumps for use in the oil fields. The mechanical parts of the pump, its operation, and performance, specifications, etc., are contained in the bulletin. Copies can be had by writing Chain Belt Company.

In New Plant

Ben F. Kelley, inventor and manufacturer of Kelco products, consisting of the Kelco safety spinning line cathead and Kelco safety air operated rotary and tubing slips, now occupies a new plant at 18 South Madison Street, Tulsa, Oklahoma.

Kelley's two sons have recently joined the firm. W. L. Kelley, who has been in the engineering department of Hanlon-Waters, Inc., is in charge of plant operations. V. A. Kelley, who has been with the Sargent Engineering Company, will devote his time to servicing Kelco products.

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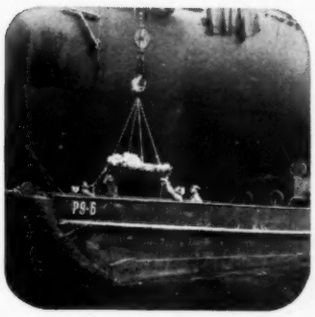

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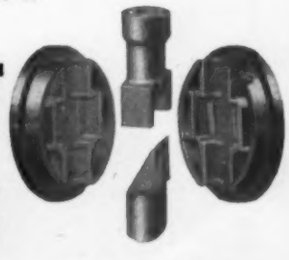

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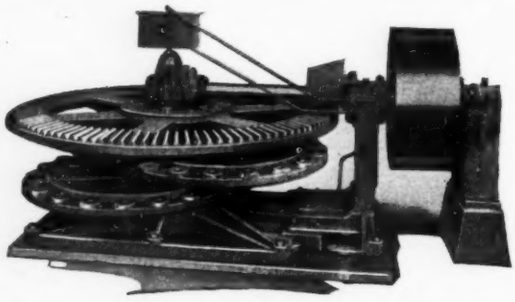

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MEETINGS

San Joaquin Valley Oil Producers Association—December 29, Hotel El Tejon, Bakersfield, California.

California Natural Gasoline Association, Monthly Meeting—January 6, Rio Hondo Golf Club, Downey, California.

Society of Automotive Engineers, Annual Meeting—January 10 ,11, 12, 13, and 14, Book-Cadillac Hotel, Detroit, Michigan.

American Institute of Mining and Metallurgical Engineers, Annual Meeting—February 20, 21, 22, 23, and 24, Waldorf-Astoria, New York, New York.

American Association of Petroleum Geologists, Society of Exploration Geophysicists, and Society of Economic Paleontologists and Mineralogists, Annual Meetings—March 22 and 23, Dallas, Texas.

American Association of Oil Well Drilling Contractors, 1944 Meeting—Fort Worth, Texas, date to be announced.

National Association of Corrosion Engineers—April 10, 11, and 12, 1944, Rice Hotel, Houston, Texas.

Natural Gasoline Association of America, Annual Meeting—April 13, 14, and 15, 1944, Baker Hotel, Dallas, Texas.

Petroleum Industry Electrical Association and the Petroleum Electric Supply Association—Last week in April, 1944, Dallas, Texas.

Southwestern Gas Measurement Short Course—June 6, 7, and 8, 1944, Norman, Oklahoma.

Beadle Made Sales Manager

Harold I. Beadle, widely known chemical engineer, has been appointed sales manager for new products of Naugatuck Chemical Division, United States Rubber Company, according to an announcement by R. E. Casey, general sales manager of the chemical division.

In this capacity, Beadle will handle sales of new synthetic rubbers and synthetic plastics for the rubber company and also new developments of the company in other fields it is exploring.

H. I. BEADLE

Beadle was graduated at Massachusetts Institute of Technology in 1923 with a degree in chemical engineering and practiced as a consulting engineer in New York City for six years.

In 1929 to 1940, he was employed by Tide Water Associated Oil Company.

Beadle later joined the organization of Commercial Investment Trust, Inc., in charge of engineering investigation in the states of Pennsylvania, New Jersey, Maryland, and Virginia.

In addition to sales activities in connection with his new assignment, he has been appointed a member of the new products committee responsible for the investigation and evaluation of new products.

Power Association Officers

At a meeting held in Dallas, Texas, December 1 the following officers were elected by the Petroleum Electric Power Association for 1944:

President: P. M. Cordell, Texas Electric Service Company, Fort Worth, Texas.

Vice president: L. B. Blalock, Texas Power and Light Company, Dallas, Texas.

Secretary: H. C. Le Vois, Gulf States Utilities Company, Beaumont, Texas.